HANDBOOK

OF

PHARMACY

EMBRACING THE 71944

THEORY AND PRACTICE OF PHARMACY

AND THE

ART OF DISPENSING.

FOR

STUDENTS OF PHARMACY AND MEDICINE, PRACTICAL PHARMACISTS, AND PHYSICIANS.

BY

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SECOND EDITION, REVISED AND ENLARGED,

WITH

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PREFACE TO SECOND EDITION.

In issuing this "Revised Edition," aside from a number of corrections and slight alterations, it was deemed expedient by the author to introduce chapters on the "Analysis of Urine" and "Applications of the Microscope in Pharmacy." Concerning the former, it is the aim to furnish the essential features in a concise form adapted to the use of the pharmacist, pharmaceutical or medical student. It has been possible in many instances to bring into relation the abnormalities of a given urine with the pathological process going on in the body, presenting the material as comprehensively as possible. Qualitative tests are given for all the normal and abnormal constituents, followed by quantitative methods of estimation. This chapter has been largely contributed by George C. Diekman, Ph. G., M. D.

The chapter on the "Applications of the Microscope in Pharmacy" is intended to familiarize the pharmacist and pharmaceutical student with the construction, handling and various applications of the microscope as applied in the examination of drugs, chemicals, food products, etc., one of the most important departments of the practice of pharmacy. This chapter was contributed by Smith Ely Jelliffe, M. D.

PREFACE.

In preparing this Handbook, the author's aim was to supply to the student of pharmacy a compendious and yet sufficiently detailed text-book for systematic study, and to those exercising the art a trustworthy guide to be consulted in daily practice. In accordance with this general plan, particular care has been bestowed upon the explanation of all operations and methods usually occurring in dispensing establishments and laboratories designed on a small scale. To give anything like a full account of modern apparatus, appliances, and methods pursued in large manufacturing establishments would have enlarged the work unnecessarily, without practical benefit to the dispensing apothecary.

The present work is divided into four parts, viz.: Physical and Mechanical Operations; Galenical Pharmacy; the Art of Dispensing; and Volumetric Analysis.

Part I, which treats of the general principles, and physical or chemical operations in their general application, presents what may be called the theory of pharmacy. A thorough knowledge of the subjects embraced in this section is of vital importance to the apothecary, in order to enable him to control the quality of the medicinal substances which he purchases or dispenses. He who is unable to apply the proper tests or make the necessary determinations himself, is compelled to rely upon statements at second hand, and is thus handicapped not only in the management of his own business, but will be unable to secure the confidence of the public or of the medical profession, either of whom will, sooner or later, find out the shallowness of his knowledge.

This portion of the work, and such of the succeeding portions as appeared to require it, have been *profusely* illustrated with drawings, diagrams, and cuts of apparatus and appliances, carefully selected from the best sources, both domestic and foreign. Processes which have become antiquated have been either entirely omitted, or are only briefly described. Some processes, as for instance that of grinding and powdering drugs on a large scale, have practically ceased to come within the province of the dispensing pharmacist, and demand machinery which is beyond the requirements of the latter; it has, therefore, received only a very brief mention. But the processes of grinding and powdering drugs on a *small* scale, and the most suitable apparatus for this purpose, have been treated of in detail. Such subjects as the

determination of melting and boiling points, evaporation, sublimation, desiccation, solution and solubility, crystallization, decantation, filtration, etc., have also been discussed at length, particularly for the benefit of students and beginners. Especial care has been bestowed on the subjects of maceration, percolation and expression.

Part II treats of the various classes of galenical preparations. Each class is described and explained as fully as its importance warrants, and in connection with each class are given descriptions and explanations of the processes of those preparations which require a commentary. Particular attention has been given to the explanation of the several steps of the processes involving chemical reactions by means of equations or diagrams, and the method of testing, as well as the application of volumetric methods of assay, are fully explained. Working processes are, as a rule, only given in the case of those preparations which require a commentary. For all others, the reader or student is referred to the U. S. Pharmacopœia, which he is expected to consult, and which this work is not designed to replace.

In connection with many of the more important preparations, examples or exercises are given which will assist in acquiring a thorough understanding of the reactions and calculations involved in the explained process.

Whenever necessary, syllabi or tables of the various preparations have been given under the several classes.

Part III embraces the Art of Dispensing. In the section treating on Prescriptions, the aim of the author has been to make it as practical as possible. Foreign methods of prescription writing and dispensing have been treated of, wherever thought necessary, alongside of those prevailing in this country, and a chapter added on homœopathic pharmacy, which is found to be a necessary occupation of the regular apothecary in some sections of the country. Much care has been devoted to the chapters on explosive or dangerous prescriptions, and on incompatibilities. The series of characteristic prescriptions, to which explanatory comments are added, will also, it is hoped, be found generally useful.

Owing to the prominence which the new Pharmacopœia gives to the volumetric methods of assay, it has been thought not only useful, but quite necessary to present this subject somewhat more at length in Part IV, so as to make the student and general user of the book thoroughly familiar with it. It is an old experience of teachers that students approach this subject frequently with reluctance, as it appears to many of them at first difficult; but that they nearly all quickly master it, as soon as they understand the simple basis upon which the whole rests.

The author desires to acknowledge his indebtedness for valuable advice and assistance received from Charles Rice, Phil. D.,

of New York City. Likewise, acknowledgments are due to Prof. J. U. Lloyd, of Cincinnati, Ohio; also, Mr. A. Zimmerman, Ph.G., and Mr. W. H. Madison, Ph. G., for assistance rendered.

Many of the illustrations in this book were selected from various text-books and works of reference, which necessarily demand proper acknowledgment. It was found impracticable to mention the source in each separate instance, hence the author deemed it best and proper that a list of these be given in detail here, viz.:—

Arbeitsmethoden für Organisch-Chemische Laboratorien; Lassar-Cohn. Leipzig: Leopold Voss.

Arzneiverordnungslehre; R. Kobert. Stuttgart: F. Enke.

Atlas zu den flüchtigen Oelen; K. L. Vetters. Weimar: F. Voigt.

Atlas zu den fetten Oelen; G. Bornemann. Weimar: F. Voigt.

Die Neueren Arzneimittel; B. Fischer. Berlin: J. Springer.

Ganot's Physics; E. Atkinson. New York: Wm. Wood & Co.

Kommentar zum Arzneibuch für das Deutsche Reich; H. Hager, B. Fischer and C. Hartwich. Berlin: J. Springer.

Commentar zur siebenten Ausgabe der oesterreichischen Pharmacopoe; F. Schneider und A. Vogl. Wien: C. Gerald.

Lehrbuch der Organischen Chemie; V. Meyer und P. Jacobson. Leipzig: Veit & Co.

Lehrbuch der Anorganischen Chemie; (Graham-Otto), A. Michaelis. Braunschweig: F. Vieweg und Sohn.

Mohr's Lehrbuch der Titrirmethode; A. Classen. Braunschweig: Vieweg.

Manual of Analytical Chemistry; J. Muter. Philadelphia: Blakiston & Co.

Ostwald's Outlines of General Chemistry; J. Walker: Macmillan & Co.

Proceedings of the American Pharmaceutical Association.

Physikalisch-Chemische Methoden; J. Traube. Leipzig: L. Voss.

Pharmaceutisches Manual; E. Dieterich. Berlin: J. Springer.

Real Encyclopaedie der Pharmacie; E. Geissler, J. Miller. Leipzig: Urban & Co

Redwood's Pharmacy, Proctor.

Treatise on Chemistry; Roscoe and Schorlemmer. Macmillan & Co.: London.

Schule der Pharmacie, I; E. Mylius. Berlin: J. Springer.

Lehrbuch der Pharmaceutischen Chemie; E. Schmidt. Braunschweig: Vieweg und Sohn.

Technik der Experimental Chemie; R. Arendt. Leipzig: Leopold Voss.

The Art of Dispensing, *Chemist and Druggist*. London.

Chemiker-Zeitung; G. Krause, Cöthen.

Pharmaceutische Centralhalle; H. Hager und E. Geissler, Dresden.

New York City,
September, 1894.

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HANDBOOK OF PHARMACY.

INTRODUCTORY.

The term "Apotheke" (ἀποθήκη) was applied in olden times to a place of storage for wines, books, etc. From this is derived "apothecary" (Lat. apothecarius). Since the Middle Age, it is restricted to those localities where medicinal substances are kept and dispensed.

The term Pharmacy, is derived from the Greek pharmakon (φάρμακον), meaning medicine. It is the art which treats of the identification, preparation, testing, and dispensing of medicinal substances.

A Pharmacopœia (from φάρμακον, medicine, and ποιεῖν, to make) is a code for the use of the apothecary and physician, which embraces the definitions, descriptions, physical and chemical properties, tests and methods of preparation of medicinal agents.

The earliest work,* which may be compared to our modern pharmacopœias, and of which we have any definite knowledge, is an Egyptian treatise, preserved to us in the Papyrus Ebers, dating back to 1552 B. C. This contains a large number of formulas, some of them quite complex, the ingredients being ordered by certain weights and measures. Nothing else has been preserved to us, in the nature of such a work, within historic times, until we descend to the age of Hippocrates (about 460 to 377 B. C.), who, with his disciples founded a school of medicine, gradually rendering necessary the employment of formularies, to secure uniformity in the preparation of medicines. Real formularies, however, were not composed until much later, about the time of Andromachus, Nero's court physician (about 60 A. D.). After Galen's time, their number gradually increased, but it was not until about the thirteenth century that more elaborate works (usually called "Antidotaria") made their appearance. The Arabian physicians and their translators during the Middle Age considerably enriched the literature in this direction. The first work which really deserves the name of a pharmacopœia was composed by Valerius Cordus, and was published, after his death, by the city of Nuremberg, in 1546. It was customary in those times to apply the name of "Dispensatorium" to formularies of this kind, and up to comparatively recent times, the term Dispensatory has been used, in

* Very exhaustive articles on the subject of Pharmacopœias and History of Pharmacy, by Dr. Chas. Rice, will be found in "A Reference Handbook of the Medical Sciences," Vol. V and Supplement Vol.—Wm. Wood & Co., N. Y.—*The Pharmaceutical Era*, January, 1895.

various countries, in the sense of our "pharmacopœia," while we now usually apply it to unofficial commentaries on the latter.

The first United States Pharmacopœia (in English and Latin) was published in Boston in 1820; this has been followed since by a new edition every ten years, prepared by a Committee of Revision appointed or elected by a convention of medical and pharmaceutical colleges and societies. Nearly all foreign pharmacopœias are issued by the authority of their respective governments; the United States Pharmacopœia is not thus issued, but at the same time it is recognized by our government.

There are a number of smaller countries which have no national pharmacopœia, but recognize those of other countries; among these, the South American States and West Indies, recognize generally the Spanish with, in some instances, the French Pharmacopœia. In China, the foreign apothecaries employ their various national pharmacopœias; while the natives usually follow a voluminous work, entitled Pun-tsao, dating back to about 1560 B. C.

Any work which takes up the various official (pharmacopœial) and non-official remedies, and treats upon them exhaustively, in all their applications and uses in Medicine and Pharmacy, is called a "Dispensatory."

TABLE OF THE MOST IMPORTANT PHARMACOPŒIAS.

Country.	Title of Pharmacopœia.	Language.	Number of Remedies.	Entered into Force.
Austria,	Pharmacopœa Austriaca. Editio septima.	Latin.	(578)	1890
Belgium,	Pharmacopœa Belgica. Editio secunda.	Latin and French.	1140	1885
Chili,	Farmacopea Chilena.	Spanish.	——	1886
Denmark,	Pharmacopœa Danica. Editio tertia.	Danish.	584	1893
England,	British Pharmacopœia.	English.	898	1885 (Supplement 1889)
Finnland,	Pharmacopœa Fennica. Editio quarta.	Latin.	400 (about)	1885
France,	Codex medicamentarius; Pharmacopée française.	French.	2039 (about)	1884
Germany,	Arzneibuch für das Deutsche Reich; dritte Ausgabe.	German.	603	1891
Greece,	'Ελληνική Φαρμακοποιία.	Latin and Greek.	976	1868
Hungary,	Magyar Gyógyszerkönyv. Második kiadás.	Latin and Hungarian.	576	1888
Japan,	Pharmacopœa Japonica. Editio altera.	Latin.	448	1891
Italy,	Farmacopea ufficiale del regno d'Italia.	Italian.	597	1892
Mexico,	Nueva Farmacopea Mexicana.	Spanish.	——	1884 (Supplement 1890)
Netherlands,	Pharmacopœa Neerlandica. Editio tertia.	Latin and Dutch.	533	1890
Norway,	Pharmacopœa Norvegica. Editio tertia.	Norwegian.	——	1893(?)
Portugal,	Pharmacopêa Portugueza.	Portuguese.	1600 (about)	1876
Roumania,	Pharmacopœa Romana.	Roumanian.	538	1874
Russia,	Rossiiskaja Pharmakopeya.	Russian.	808	1891
Sweden,	Pharmacopœa Suecica. Editio octava.	Swedish.	——	1893
Switzerland,	Pharmacopœa Helvetica III.	German-French-Italian.	1038	1894
Spain,	Farmacopœa oficial Española. Sexta edicion.	Spanish.	1598	1884
United States of America,	Pharmacopœia of the United States of America. Seventh decennial revision.	English.	994	1893

In earlier times, the different pharmacopœias or treatises appeared entirely in the Latin language; of late years, however, the text of these works has usually been written in the native language of the country in which it is issued, the Latin being retained in the various titles.

Latin has been retained, chiefly because, being a dead language, it is not subject to the various changes and modifications of the different modern tongues. Even with the employment of Latin, various pharmacopœias differ slightly in their nomenclature; thus in the case of the chemicals, one will place the electro-positive, another the electro-negative element first; for instance, sulphate of iron is variously named Ferrum sulphuricum, Ferri sulphas, Sulphas ferri and Sulphas ferrosus. Some pharmacopœias employ the term kalium for potassium and natrium for sodium. In the Dutch, Danish, and Swedish pharmacopœias, the titles of the chemical salts are expressed by treating the base as an adjective placed after the general name of the salt, corresponding, for example, to the English "Sodic Sulphate." For Potassii acetas or Kalium aceticum they have Acetas kalicus; for Sodii bromidum or Natrium bromatum they have Brometum natricum; for Bismuthi subnitras or Bismuthum subnitricum they have Subnitras bismuthicus.

The various parts of the text of each article in the U. S. Pharmacopœia are arranged in the following order:—

1. The official Latin title.
2. The English title.
3. In the case of chemicals, the symbolic formula and molecular weight.
4. In certain cases, one or more synonyms.
5. Definition, wherever necessary.
6. Mode of keeping, where necessary.
7. Description, physical, chemical, or botanical, followed, where necessary, by tests of identity, purity, and strength.
8. Preparations which may be considered as forms of administration of the drug.

1st. *The Official Latin Title.*—This is expressed in Latin, and is intended to express concisely the nature of the chemical, drug, or plant-part recognized. The U. S. P. ignores all remedies not included in itself, hence only that part of a drug or plant is used which it recognizes. Thus, under the title Aconitum, the Pharmacopœia refers only to the *tuber*, and to no other part of the Aconitum napellus. When two different parts of a plant are recognized, then the Latin name of the particular part is added to the title; thus, "Belladonnæ Folia" for belladonna leaves, and "Belladonnæ Radix" for the root. For the galenical preparations, such titles are selected as will most nearly indicate the nature or the composition of the preparation, attention being given also to simplicity and brevity of expression. Thus, "Pulvis Ipecacuanhæ et Opii" indicates at once the composition of the

powder; but where several constituents enter into the composition of a preparation, the title includes only the main constituent, the remainder being indicated by the term *compositus*.

The various pharmacopœial titles conform to the rules of Latin grammar.* Thus, we write: Solution of Potassa, Liquor (nominative) Potassæ (genitive); Cyanide of Mercury, Hydrargyri (gen.) Cyanidum (nom.); Pills of Phosphorus, Pilulæ (nom. plural) Phosphori (gen.). Where there are two different oxides, iodides, or salts of the same base, a distinguishing adjective is usually appended in order to discriminate between the two; thus, we distinguish the two chlorides of mercury by the adjectives "corrosivum" and "mite," respectively.

When an adjective is employed, it must agree in gender with the principal noun; thus, the masculine form "compositus" (compound) becomes "composita" with feminines, and "compositum" with neuters. We write Pulvis Cretæ Compositus (masc.), Tinctura Benzoini Composita (fem.), and Decoctum Sarsaparillæ Compositum (neut.).

2d. *The English Title.*—That is, the English name which the Pharmacopœia selects or coins to designate the article. Very generally, this is identical with the vernacular name of the article, or that by which it is known in the market. In some cases the Pharmacopœia coins a new name, for valid reasons. In the case of vegetable drugs, the genus name of the plant is often selected as the official English title, so that in many cases the official Latin title and the English title are identical.

3d. *The Symbolic Formula and Molecular Weight.*—In writing the symbolic formulas of acids, the replaceable hydrogen atoms are written before the other elements (thus, HCl, H_2SO_4, H_3PO_4, $HC_2H_3O_2$, etc.). A period is used in the case of some compounds, where it is desired to show the existence of several intimately connected radicals or constituents (thus, in Ammonium Carbonate, $NH_4HCO_3.NH_4NH_2CO_2$). Water of crystallization is separated from the formula of its salt by a + sign.

4th. *The Synonym*, that is, the name by which the article is popularly known.—Synonyms are only added where special reasons exist; for instance, where the English title introduced by the Pharmacopœia is not usually employed in commerce, or where a change has been made either in the Latin or English title, and attention is to be drawn to this. For example, under the title "Hydrargyri Oxidum Rubrum" we have the synonyms "Red Mercuric Oxide" and "Red Precipitate;" this latter name arises from its old title, "Mercurius Precipitatus Ruber." Salts of hydrochloric acid have formerly been called muriates, the term being derived from *muria* (salt water).

The term Cremor (crême) was applied during the Middle Age to substances which separated on the surface of a fluid; later,

* A good work of reference is Robinson's "Latin Grammar of Pharmacy and Medicine."

this term was applied to *all* precipitates; hence this title was given to the acid potassium tartrate (argols) which precipitates on the sides of wine casks, being called Cremor tartari, hence the source of the synonym, Cream of Tartar. These synonyms are sometimes misleading and inaccurate; for instance, sugar of lead for Plumbi acetas, or white vitriol for Zinci sulphas, or blue vitriol for Cupri sulphas.

5th. *The Pharmacopœial Definition.*—This is not necessary in all cases, but, where applied, it embraces in a few words a description of the chemical or botanical nature and source of the substance. Thus, the U. S. P. defines Coca as "the leaves of *Erythroxylon Coca* Lamarck (nat. ord. Lineæ)," and Gallic Acid as "an organic acid, usually prepared from tannic acid."

6th. *Modes of Keeping.*—In those instances where the preparation or drug is sensitive to the influence of air, light, heat, etc., the Pharmacopœia specifies that certain precautions should be taken in regard to its proper preservation.

7th. *The Description.*—This is intended to be a concise statement of the characteristic physical properties of the drug, followed wherever necessary, and particularly so in the case of chemicals, by tests of identity and purity.

PART I.

PHYSICAL AND MECHANICAL OPERATIONS.

CHAPTER I.

WEIGHTS AND MEASURES.*

A perfect system of Metrology should bear a simple relation to some constant and indestructible object, the length or size of which is known or can be readily determined with accuracy. Any three units (of which no *one* is derivable from the other two) may be selected as fundamental units. In the systems in present use the units of Length, Mass, and Time have been selected as fundamental units, and the various systems of absolute units differ only as to the particular unit selected for measurement of Length, Mass, and Time. Mass and Weight are not identical. Mass is constant; it is the *quantity* of matter. Weight is the force with which the mass is drawn toward the center of the earth. The weight of Mass varies. When a body (Mass) is attached to a spiral balance (Jolly's) and weighed at the sea-level, then on a mountain-top, it will be found to have decreased, and at the equator it will weigh less than at the poles. At the equator of the sun a pound would weigh 27.62 lbs., owing to the difference in the force of gravity. When we say a body weighs 10 pounds, we mean that the body is drawn toward the earth with ten times the force with which the standard pound is drawn toward the earth.

THE UNIT OF TIME is the *Second.* This is $\frac{1}{86400}$ of the mean solar day.

THE UNIT OF LENGTH, recognized as the standard in England and North America, is the English *Yard* of 36 inches. The yard and inch were formerly based upon a standard yard-stick in the custody of the British Board of Trade. Later on, it was found that a pendulum swinging seconds of time in vacuo at the level of the mid-tide in the latitude of London, measured 39.13929 inches, such as are derived from the standard yard. Should the latter become lost or destroyed, therefore, a new standard yard identical with the present one may readily be constructed.

THE UNIT OF LENGTH, or absolute standard, is the *Meter*, a ten-millionth part of the earth's quadrant (from pole to equator). As this unit was based on calculation, a practical standard was

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* A good work of reference is Oldberg's "Manual of Weights and Measures."

constructed by marking the above-mentioned distance on a bar made of an alloy of platinum and iridium (chosen because of its great hardness and durability) preserved in the French Archives. Copies of this were furnished to all nations which bore a share of the expense: among others, to this country. The meter is the compulsory standard of measure in all civilized countries except the United States and Great Britain; it is the recognized standard for all scientific observations.

THE UNIT OF WEIGHT.—The British standard *Pound* is a certain mass of platinum in the London Standards Office. If one cubic inch of distilled water, in vacuo, weighs 252.892 grains, then the standard pound contains 5760 of these grains.

The unit of weight is the *Kilogramme*, a mass of platinum kept in the French Archives, copies of which were also furnished to certain other countries among them the U. S. This is the weight of $\frac{1}{1000}$ part of a cubic meter, or the weight of one cubic decimeter of distilled water at its greatest density (4° C.).

Weight * has always been determined from *Measure.* From the remotest of times, we find various physical standards of weight and measure. The ancient Egyptians employed the Cubit and Foot, for which the human body furnished the basis. The Greek Talent was obtained from a cubic foot of water, and the Mina, or the $\frac{1}{100}$ part of this, is nearly identical with the modern Pound. Two distinct pounds have always been in use, one for *monetary*, and one for *commercial* purposes.

The oldest known set of standard weights was discovered in the ruins of Nineveh by Mr. Layard. The earliest standard in England was the old Saxon pound, identical with the old Apothecaries' pound of Germany (5500 Troy grains). The Pound Sterling was determined from this weight in silver.

In 1266, Henry III decreed the following standards: "32 grains of wheat from the middle of the ear, well dried, should weigh a pennyweight, of which 20 should go to the ounce;" twelve such ounces made the pound, eight pounds one gallon of wine.

The denomination of the grain originated with the French. The term "Troy," as applied to this system, is derived from the fact that it was brought from the East at the time of the Crusades, and first adopted at Troyes, a commercial town of France. The Troy weights were readily adopted by jewelers and apothecaries for the sake of convenience. The term "Karat" is employed by jewelers, being equivalent to four Troy grains; when meant to express the fineness of gold, the karat means the twenty-fourth part; thus, 14-karat gold means $\frac{14}{24}$ of gold and $\frac{10}{24}$ of base metal. Troy weights are no longer employed in medicine. Sometimes

* **True and Apparent Weight.**—The *true* weight of a body is its weight "in vacuo." The *apparent weight* is its weight in air under ordinary conditions of atmospheric pressure and temperature. This *apparent* weight of a body weighed in any medium, as air or water, is less than its true weight, the difference being the weight of the air or water displaced by the body itself, less the weight of the air or water displaced by the weights used. In pharmacy and ordinary commercial weighing the apparent weight only is considered.

the words "Troy ounce" are employed, meaning the apothecaries' ounce. Both are the same, being, however, differently subdivided.

FIG. 1.

The Pound Weight—Ancient and Modern Standards.*

1. Exchequer Standard Avoirdupois Pound of Queen Elizabeth. 2. Assyrian Bronze Lion Standard Weight. 3. Assyrian Stone Duck Standard Weight. 4. Form of Modern Local Standard Avoirdupois Weight. 5. Official Secondary Standard Pound of Gilt Metal. 6. Imperial Standard of Platinum. 7. Platinum Troy Pound of the Royal Society. 8. Platinum Troy Pound of the Standard Department. 9. Standard Troy Pound of 1758. 10. Exchequer Standard Troy Pound of Queen Elizabeth.

TROY WEIGHT.

24 grains,	1 pennyweight.	
20 pennyweights,	1 ounce,	480 grains.
12 ounces,	1 pound,	5760 grains.

SIGNS.

Grain,	Gr. or gr.
Ounce,	Oz. or oz. Troy.
Pound,	lb.

* Illustration taken from article by F. H. Taylor, *Western Druggist*, 1892, p. 175.

APOTHECARIES' WEIGHT.

20 grains,	1 scruple.	
3 scruples,	1 drachm,	60 grains.
8 drachms,	1 ounce,	480 grains.
12 ounces,	1 pound,	5760 grains.

SIGNS.

Grain,	Gr. or gr.
Scruple,	℈.
Drachm,	ʒ.
Ounce,	℥.
Pound,	℔.

AVOIRDUPOIS WEIGHT.

This system first appears in use at the time of Edward III (1327–1377), who decreed that "we will, and establish, that one weight, one measure, and one yard be throughout the land, and that woolens and all manner of avoirdupois be weighed." The term "avoirdupois" is derived from *aver* or *avoirs* (Fr.), meaning "havings," the old appellation for portable goods, chattels, etc., and *poids* (Fr.), meaning "weight,"—"*aver de pois*," goods of weight. In time, the term lost its meaning, and later, at the time of Henry VIII (1532), it was ordered that "beef, pork, mutton, and veal shall be sold by weight" called "haverdupois;" hence, in early times, the term was applied to goods themselves, and later on to the system of weights employed for these kinds of goods.

All goods bought by the apothecary are weighed by the avoirdupois system. For instance, a ⅛-ounce vial of morphine does not contain ⅛ of 480 grains, but ⅛ of 437.5 grains, or 54.68 grains; or one ounce of sulphate of quinine is 437.5 grains, and not 480.

AVOIRDUPOIS WEIGHT.

437.5	grains,	1 ounce.	
16	ounces,	1 pound,	7000 grains.
100	pounds,	1 hundredweight.	
20	hundredweights,	1 ton.	

SIGNS.

Ounce,	Oz. or oz.
Pound,	℔.
Hundredweight,	cwt.
Ton,	T.

We have one unit common to all, viz.: "the grain." The Troy ounce contains 42.5 grains more than the Avoirdupois ounce. The Troy pound contains 1240 grains less than the Avoirdupois pound.

Avoirdupois,	437.5 grains in ounce,	7000 grains in pound.
Troy,	480.0 grains in ounce,	5760 grains in pound.
Difference,	42.5 grains.	1240 grains.

The term "grain," is derived from Latin "granum," and was originally based on the weight of a grain of wheat as already stated. Its value is now derived from the weight of a cubic inch of distilled water, weighed in vacuo against brass weights, at 60° F., under a barometric pressure of 30 inches; this, according to the latest calculation, is said to be 252.892 grains.

In 1834, the English standards of weight and measure, consisting of a yard and a pound Troy of brass, were destroyed at the burning of the Houses of Parliament. Prior to this, great confusion existed, three different gallons being in use: The Wine gallon of 231, Corn gallon of 268, and Ale gallon of 282 cubic inches. After this, a revision and restoration was resolved upon, since the duplicates of the standards of brass had suffered oxidation. A cubic inch of distilled water weighed in air, against brass weights (of density of 8.3) at the temperature of 62° F., and the barometer at 30 inches (760 Mm.), was determined to be equal to 252.458* grains, of which the standard Troy pound contains 5760. As to the unit of length, they adopted the length of a pendulum, swinging seconds of mean time, in a vacuum, at the level of mid-tide in the latitude of London (or 39.13929 inches). From this is now derived the new British standard yard, which is the length at 62° F., between two marks, on the gold plugs of a bronze bar in the Standards Office, London, being 36 of the before-mentioned inches.

The Imperial gallon contains 277.24 cubic inches; the Wine gallon being 231 cubic inches. In 1826 this set of weights and measures was finally adopted as a rival to the Metric system, which was then being introduced from France. This system is now employed in medicine and pharmacy in Great Britain. The Imperial standard pound is declared to be the *true* weight of an avoirdupois pound in a vacuum. The Imperial standard of platinum balances the brass weights in a vacuum. The volume of 70,000 grains, or 10 avoirdupois pounds, of pure water at 62° F., and barometer at 30 inches, is the Imperial gallon. The Imperial pint is divided into 20 fluidounces, and weighs at 62° F. 20 avoirdupois ounces. The gallon, quart, and pint are nearly 20 per cent. larger than the corresponding volumes in wine measure. The fluidounce is about four per cent. smaller than the United States fluidounce.

The weights and measures employed in the United States are assumed to be copies of the units of weight, and of the old wine and Winchester measures, formerly employed in England, which were discarded years ago.

In 1827 the United States procured a copy of the British brass Troy pound for the use of the Mint. This was declared by law in

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* The value now employed by the United States Coast and Geodetic Survey is 252.338 grains, based on the French determination of the mass of a cubic decimeter of water at its maximum density.

1873 to be the "standard Troy pound of the Mint of the United States, to which the coinage thereof shall be regulated." This is the only actual standard we have, a copy of a standard long discarded. Our wine gallon of 231 cubic inches was many years ago abolished by England. So our present system of weights and measures rests upon discarded standards. The Metric System was made lawful, though not compulsory, by Act of Congress in 1866.

United States Liquid Measure.

(The unit of capacity for liquids is the wine gallon of 231 cubic inches.)

			Signs.
4 gills,	1 pint.	Gill,	gi.
2 pints,	1 quart.	Pint,	pt.
4 quarts,	1 gallon.	Quart,	qt.
		Gallon,	gal.

United States Apothecaries' or Wine Measure.

60 minims,	1 fl. drachm.			
8 fl. drachms,	1 fl. ounce,	480 minims.		
16 fl. ounces,	1 pint,	128 fl. drachms,	7680 minims.	
8 pints,	1 gallon,	128 fl. ounces,	1024 fl. drachms,	61,440 minims.

Signs.

Minim,	♏.
Fluidrachm,	f℥.
Fluidounce,	f℥.
Pint,	O.
Gallon,	Cong. or C.

Distilled Water at 15.5° C. (60° F.).

1 minim,		0.95	grains	weight.
60 minims,	1 fluidrachm,	56.96	"	"
480 "	1 fluidounce,	455.69	"	"
7,680 "	1 fluid pint,	7,291.11	"	"
61,440 "	1 fluid gallon,	58,328.88	"	"

Imperial Measure, B. P.

(1 Imperial Gallon, ... 277.274 cubic inches.)

60 minims,	1 fl. drachm.			
8 fl. drachms,	1 fl. ounce,	480 minims.		
20 fl. ounces,	1 pint,	160 fl. drachms,	9600 minims.	
8 pints,	1 gallon,	160 fl. ounces,	1280 fl. drachms,	76,800 minims.

Equivalents of Imperial Measure in United States Fluid Measure.

(The Imperial Gallon being the weight of 10 avoirdupois pounds of distilled water at 60° F. (15.5° C.).

Imperial Measure.	*United States Wine Measure.*		
1 minim.	0.96	minims.	
1 fluidrachm,	57.60	"	
1 fluidounce,	460.86	"	7.68 fluidrachms.
1 fluid pint,	9.217.34	"	19.202 fluidounces.
1 gallon,	73,738.75	"	9.601 pints.

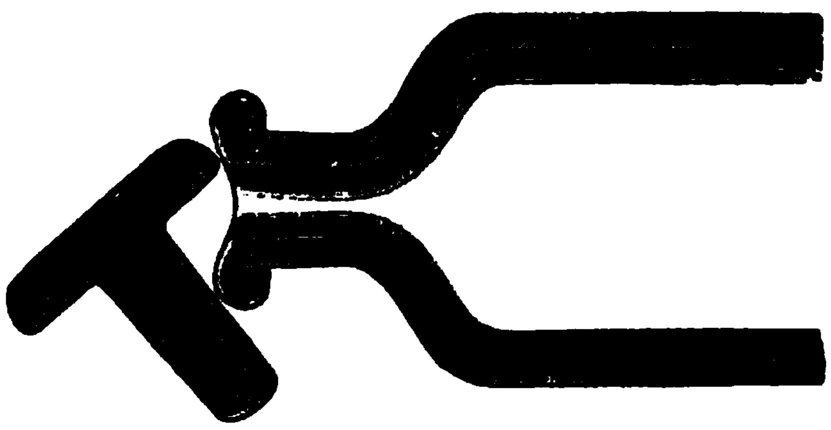
We have thus four different ounces: the Troy of 480 grains, the Avoirdupois of 437.5 grains, the Fluidounce of 480 minims or 455.69 grains,* the Imperial B. P. fluidounce of 460.86 (U. S.) minims or 437.5 grains.

The *Minim* is a very convenient unit of fluid measure; it is nearly equal to the average "drop" of distilled water.† A minim of distilled water at normal temperature weighs 0.95 grain. The drop varies in size. The measurement of liquids by drops does not give uniform or accurate results. A drop is the resultant of three forces,—gravity, cohesion, and adhesion,—and as these vary, so do drops vary in size; heavy mobile liquids form small drops, viscid liquids form large drops. The quantity of liquid in the vessel, the rapidity of dropping, the size and shape of the lip of the vessel (influencing the adhesive force), and the temperature of the liquid, are all conditions which influence the size of drops.

Aqueous solutions average	50 to 60	minims to the fluidrachm.
Fixed oils "	65 to 80	" " " "
Volatile oils "	90 to 110	" " " "
Alcohol and alcoholic liquids	120 to 140	" " " "
Ethereal liquids	200 to 300	" " " "

Foreign pharmacists, who are accustomed to weigh fluids, measure the fluid in drops for quantities weighing less than two

FIG. 2.



Position of Stopper for Dropping.

grammes. Some pharmacopœias state that, on an average, from 20 to 25 drops of distilled water are equivalent to one gramme (one cubic centimeter). Some of these give tables of the number of drops equivalent to the gramme of each of the official liquids. Thus water, aqueous solutions, fixed oils, heavy volatile oils, tinctures, fluid extracts, etc., may be reckoned as 20 drops to the gramme, light volatile oils, ethereal liquids (Spiritus Ætheris Compositus, Spiritus Ætheris, etc.), as 25 drops, and ether as 50 drops to the gramme. When drops are to be measured, the bottle should not be over three-fourths filled; then by means of the stopper, moisten the neck and lip, and allow

* Variously stated as 455.6216, 455.6994, and 455.6910 grains. Consult Oldberg's "Manual of Weights and Measures."

† Drops vary from one-fifth to one-fourth of a minim.

the liquid to flow slowly past the stopper held at an angle to the lip (Fig. 2). This insures more regularity in the size of the drops, and prevents the liquid from forming a stream.

There are a great variety of arrangements for producing drops; none however, are capable of producing drops of the same size from different liquids.

FIG. 3. FIG. 4. FIG. 5.

Vials for Producing Drops.

It is customary for many pharmacists to note on the label of the dispensing bottle the number of drops to the gramme in each special case.

APPROXIMATE MEASURES.

The following is the approximate capacity of the various household measures:—

A tumblerful,	f℥viij.
A teacupful,	f℥iv.
A wineglassful,	f℥ij.
A tablespoonful,	fʒiv.
A dessertspoonful,	fʒij.
A teaspoonful,	fʒj.

DROPS IN A FLUIDRACHM.

A TABLE SHOWING THE NUMBER OF DROPS IN A FLUIDRACHM, ALSO THE WEIGHT OF ONE FLUIDRACHM IN GRAINS AND GRAMMES FOR EACH OF THE PREPARATIONS NAMED.

From a list by S. L. Talbot, Printed in "Era Dose Book," and corrected to agree with the U. S. P., 1890.

NAME.	DROPS IN FLUIDRACHM, 60 MIN.	WEIGHT OF FLUIDRACHM.	
		In Grains.	In Gms.
Acetum Opii,	90	61	3.95
Scillæ,	68	57	3.69
Acidum Aceticum,	108	58	3.75
Aceticum Dilutum,	68	55	3.56
Carbolicum,	111	59	3.82
Hydrochloricum,	70	65	4.21
Dilutum,	60	56	3.62
Hydrocyanicum Dilutum,	60	54	3.49
Lacticum,	111	66	4.25
Nitricum,	102	77	4.98
Dilutum,	60	58	3.62
Nitrohydrochloricum,	76	66	4.27
Phosphoricum Dilutum,	59	57	3.69
Sulphuricum,	128	101	6.54
Aromaticum,	146	53	3.43
Dilutum,	60	58.5	3.79
Sulphurosum,	59	55	3.56
Æther,	178	39	2.52
Alcohol,	146	44	2.85
Dilutum,	137	49	3.17
Aqua,	60	55	3.56
Ammoniæ Fortior,	66	50	3.24
Destillata,	60	53.5	3.46
Balsamum Peruvianum,	101	60	3.88
Bromum,	250	165	10.69
Chloroformum,	250	80	5.18
Copaiba,	110	51	3.30
Creosotum,	122	56.5	3.66
Extractum Belladonnæ Radicis Fluidum,	156	57	3.69
Cimicifugæ Fluidum,	147	48	3.11
Cinchonæ Fluidum,	138	58	3.75
Colchici Radicis Fluidum,	160	37	3.69
Seminis Fluidum,	158	55	3.56
Digitalis Fluidum,	134	62	4.01
Gelsemii Fluidum,	149	49	3.14
Hyoscyami Fluidum,	160	59	3.82
Ipecacuanhæ Fluidum,	120	60	3.88
Pareiræ Fluidum,	140	51	3.72
Rhei Fluidum,	158	61	3.95
Sarsaparillæ Fluidum Compositum,	134	60	3.88
Senegæ Fluidum,	137	62	4.01
Serpentariæ Fluidum,	148	47	3.07
Uvæ Ursi Fluidum,	137	60	3.88
Valerianæ Fluidum,	150	49	3.17
Veratri Viridis Fluidum,	150	50	3.24
Zingiberis Fluidum,	142	48	3.11
Glycerinum,	67	68	4.40
Liquor Acidi Arsenosi,	57	55	3.56
Ammonii Acetatis,	75	56	3.62
Arseni et Hydrargyri Iodidi,	58	55	3.56
Ferri Citratis,	71	72	4.66
Nitratis,	59	59	3.82
Subsulphatis,	73	83	5.37
Tersulphatis,	83	72	4.66
Liquor Hydrargyri Nitratis,	131	123	7.97
Iodi Compositus,	63	59	3.82
Potassæ,	62	58	3.75
Potassii Arsenitis,	57	55	3.56
Sodæ Chloratæ,	63	62	4.01
Zinci Chloridi,	89	88	5.70
Oleoresina Aspidii,	130	52	3.36
Capsici,	120	51	3.30
Cubebæ,	123	52	3.36
Oleum Æthereum,	125	50	3.24
Amygdalæ Amaræ,	115	55	3.56
Expressum,	108	48.5	3.14
Anisi,	119	54	3.49
Bergamottæ,	130	46	2.98
Cari,	132	50	3.24
Caryophylli,	130	57	3.69
Cinnamomi,	126	53.5	3.46
Copaibæ,	123	49.5	3.20
Cubebæ,	125	51	3.30
Fœniculi,	125	53	3.43
Gaultheriæ,	125	62	4.01
Juniperi,	148	49	3.17
Lavandulæ Florum,	138	52	3.36
Limonis,	129	47	3.04
Menthæ Piperitæ,	129	50	3.24
Ricini,	77	51.5	3.33
Rosæ,	132	47	3.04
Rosmarini,	143	50	3.24
Sassafras,	133	58	3.75
Terebinthinæ,	136	45.5	2.94
Tiglii,	104	50	3.24
Spiritus Ætheris Compositus,	148	45	2.91
Ætheris Nitrosi,	146	47	3.04
Ammoniæ Aromaticus,	142	48	3.11
Chloroformi,	150	48	3.11
Menthæ Piperitæ,	142	47	3.04
Syrupus,	65	72	4.66
Ferri Iodidi,	65	77	4.98
Tinctura Aconiti,	146	46	2.98
Belladonnæ Foliorum,	137	53	3.43
Cantharidis,	131	51	3.33
Cinchonæ Composita,	140	49	3.17
Digitalis,	128	53	3.43
Ferri Chloridi,	150	53	3.43
Iodi,	148	47	3.04
Nucis Vomicæ,	140	44	2.85
Opii,	130	53	3.43
Camphorata,	130	52	3.36
Deodorati,	110	54	3.49
Valerianæ,	130	52	3.36
Veratri Viridis,	145	46	2.98
Zingiberis,	144	46	2.98
Vinum Colchici Radicis,	107	55	3.56
Colchici Seminis,	111	54	3.49
Opii,	100	55	3.56

METRIC SYSTEM, OR DECIMAL SYSTEM.

This originated in France in 1790, with the selection of a definite value, the one ten-millionth part of the earth's quadrant, the calculated distance from the earth's equator to the pole; this

value can be calculated at any time it may be necessary. Any material object may be taken as a standard for a system, provided it represents a fixed and absolute value, which can always be calculated and reproduced, should the standard be lost. This is fulfilled by the Metric System. Its name originated from the Greek word μέτρον, meaning "measure." The original standard Meter, represented by the distance between certain marks on a bar of platinum, is preserved in the French Archives in Paris, duplicates of which have been furnished to a number of other countries. It is universally employed in scientific work, and is the legal standard in most European countries, except Great Britain, receiving official sanction in the English-speaking countries. Although Washington called the attention of Congress to the advantages of this system in 1795, and Madison in 1816, again later in 1821, it did not receive official recognition until the year 1866, when, by act of Congress, it was declared "lawful in the United States to employ the weights and measures of the metric system." It was officially introduced into the Marine Hospital service, and later endorsed by various scientific societies. The U. S. Pharmacopœia of 1890 has adopted the system entirely.

For the student, in learning this system, it is preferable to refrain from comparing each term, mentally, with the corresponding term in the system familiar to him. Such comparisons or conversions have, of course, frequently to be made, but while fixing the system into the memory, it is best to treat it independently of any other system.

The *Metric System* is based on the METER, which is the standard unit of linear measurement.

THE STANDARD METRIC UNIT OF WEIGHT is the weight of one cubic decimeter of pure water at 4° C., represented by a piece of metal preserved at Paris, called the *Kilogramme.*

THE STANDARD UNIT OF VOLUME is the *Liter*, which is the volume of one cubic decimeter of pure water at 4° C. (weighing one *Kilogramme*).

Of these standards, there are a few derivatives commonly employed, namely, the *cubic centimeter*, which is a volume-capacity represented by a cube, each face of which is 1-100 of a meter, 1000 of these constituting a *Liter.*

The *gramme* is the weight of one cubic centimeter of pure water at its greatest density (4° C.). 1000 grammes constitute the kilogramme.

This system is called decimal, since the various units and parts thereof are derived from the standard unit by a system of decimals (decem—10).

On the same principle we divide our dollar into fractions, represented by tenths, hundredths, or thousandths, or we make multiples of it, in tens, hundreds, and thousands. For the sake of simplicity, a system of prefixes is employed derived from Greek

numerals to express the upward scale, or multiple values, and from Latin numerals to express the downward scale, or decimal fractions.

Greek increases	Deca, . . . 10	times.		Latin decreases	Deci, . . 1-10	part.
	Hecto, . . 100	"			Centi, . . 1-100	"
	Kilo, . . . 1000	"			Milli, . . 1-1000	"

In the following table we find a general view of the system with its application of decimals:—

1000	Kilometer,	1000	Kiloliter,	1000	Kilogramme,
100	Hectometer,	100	Hectoliter,	100	Hectogramme,
10	Dekameter,	10	Dekaliter,	10	Dekagramme,
1	Meter,	1	Liter,	1	Gramme,
0.1	Decimeter,	0.1	Deciliter,	0.1	Decigramme,
0.01	Centimeter,	0.01	Centiliter,	0.01	Centigramme,
0.001	Millimeter,	0.001	Milliliter,	0.001	Milligramme,

The abbreviations more frequently employed are the following:—

M., ... meter.
Cm., ... centimeter.
Mm., ... millimeter.
L., ... liter.
Cc., ... cubic centimeter.
Gm., ... gramme.
Cg., ... centigramme.
Mg., ... milligramme.

1 milligramme	=	0.001 gramme					
10 milligrammes	=	1	centigramme	= 0.01 gramme			
100 "		10	"	1	decigramme	= 0.1 gramme	
1000 "		100	"	10	"	1.0	"

All of the before-mentioned terms are not in common use. Of *weights*, the kilogramme (often called simply the Kilo), gramme, centigramme, and milligramme are usually employed in pronouncing a given weight. For instance, 16.143 Gm. is not read "sixteen grammes, one decigramme, four centigrammes, and three milligrammes," but "16 grammes and 143 milligrammes."

Of measures of *capacity*, only the liter and cubic centimeter are usually employed.

Of measures of *length*, the meter, centimeter, and millimeter are commonly in use. In microscopic work, the thousandth part of a millimeter (micromillimeter—mkm; also called micron, the symbol of which is μ) is often employed.

One side of the cube (Fig. 6) is supposed to measure one-tenth of a meter or one decimeter, and if each side be the same, the capacity of the cube represents one liter (1000 Cc.); the lower edge is divided into ten parts, each representing in length the one-hundredth part of a meter, or one centimeter; the capacity of a cube constructed on this, represents one cubic centimeter, which

when filled with pure water at 4° C. weighs one gramme; the upper edge is subdivided into centimeters ($\frac{1}{100}$) and millimeters, ($\frac{1}{1000}$).

For the purpose of approximately converting terms of the Metric into our own United States system, and *vice versa*, it is

FIG. 6.

Metric Diagram—Comparison of Measures of Length, Capacity, Weight.

not necessary, for practical purposes, to apply a series of rules, but merely to remember the comparative value of the chief standards. For instance:—

1 meter (for measures of length), ... 39.37 inches.
1 gramme (for measures of weight), ... 15.432 grains.
1 cubic centimeter (for measures of capacity), 16.23 minims (about 30 Cc. = 1 U. S. fluidounce).

From these we can readily calculate the different values:—

1 meter, ...	39.37 inches.		
1 decimeter, ...	3.93 "		
1 centimeter, ...	0.39 "	or about $\frac{2}{5}$ of an inch.	
1 millimeter, ...	0.039 "	" " $\frac{1}{25}$ " " "	

1 gramme, ...	15.432 grains.	
1 decigramme, ...	1.5432 "	
1 centigramme, ...	0.15432 "	or about $\frac{1}{6}$ of a grain.
1 milligramme, ...	0.015432 "	" " $\frac{1}{64}$ " "
1 kilogramme, ...	15432 "	" " 2.2 av. lbs.

1 cubic centimeter, ...	16.23 minims, or about $\frac{1}{4}$ U. S. fluidrachm.		
4 Cc., ...	about	1	fluidrachm (3.697 Cc.).
15 Cc., ...	"	4	fluidrachms (14.787 Cc.).
30 Cc., ...	"	1	fluidounce (29.573 Cc.).
250 Cc., ...	"	$8\frac{1}{2}$	fluidounces.
500 Cc., ...	"	17	" (502.75 Cc.).
1000 Cc. (1 liter), ...	"	33.8	" or $2\frac{1}{8}$ pints.

The above figures are approximately correct and answer for all practical purposes.

For table of equivalents of the various systems refer to the Appendix.

For reading and writing the various quantities of the Metric system, the following examples may be given:—

25 grammes are written, ...	25.0	(25×1.0, ... 25.0)
25 decigrammes are written, . . .	2.5	(25×0.1, ... 2.5)
25 centigrammes " " . . .	0.25	(25×0.01, ... 0.25)
25 milligrammes " " . . .	0.025	(25×0.001, ... 0.025)

or

1000 grammes are written, . . .	1000.0	or 1 Kilo, ... 1 Kg.
500 " " " . . .	500.0	" $\frac{1}{2}$ Kg.
250 " " " . . .	250.0	" $\frac{1}{4}$ Kg.
100 decigrammes are written, . .	10.0	(100×0.1, ... 10.)
100 centigrammes " " . .	1.0	(100×0.01, ... 1.0)
100 milligrammes " " . .	0.1	(100×0.001, . . . 0.1)
1000 cubic centimeters are written, ...	1000 Cc.,	or 1 Liter.
500 " " " "	500 Cc.,	" $\frac{1}{2}$ "
250 " " " "	250 Cc.,	" $\frac{1}{4}$ "

EQUIVALENTS OF METRIC WEIGHTS AND MEASURES.*

Avoirdupois Weight in Grammes.

1-16 oz.	=	1.772 grammes.
1/8 oz.	=	3.544 grammes.
1/4 oz.	=	7.088 grammes.
1/2 oz.	=	14.175 grammes.
1 oz.	=	28.350 grammes.
2 ozs.	=	56.699 grammes.
3 ozs.	=	85.049 grammes.
4 ozs.	=	113.398 grammes.
5 ozs.	=	141.748 grammes.
6 ozs.	=	·170.098 grammes.
7 ozs.	=	198.447 grammes.
8 ozs.	=	226.796 grammes.
9 ozs.	=	255.146 grammes.
10 ozs.	=	283.496 grammes.
11 ozs.	=	311.846 grammes.
12 ozs.	=	340.195 grammes.
13 ozs.	=	367.544 grammes.
14 ozs.	=	396 894 grammes.
15 ozs.	=	425.243 grammes.
1 pound	=	453.592 grammes.
2 pounds	=	907.18 grammes.
3 pounds	=	1360.78 grammes.
4 pounds	=	1814.37 grammes.
5 pounds	=	2267.96 grammes.
6 pounds	=	2721.55 grammes.
7 pounds	=	3175.14 grammes.
8 pounds	=	3628.74 grammes.
9 pounds	=	4082 33 grammes.
10 pounds	=	5435.92 grammes.

U. S. Fluid Measure in Cubic Centimeters.

1 minim	=	.06 cubic centimeter.
2 minims	=	.12 cubic centimeter.
3 minims	=	.18 cubic centimeter.
4 minims	=	.25 cubic centimeter.
5 minims	=	.31 cubic centimeter.
10 minims	=	.62 cubic centimeter.
20 minims	=	1.23 cubic centimeters.
30 minims	=	1.85 cubic centimeters.
1 fluidrachm	=	3.70 cubic centimeters.
2 fluidrachms	=	7.39 cubic centimeters.
3 fluidrachms	=	11.09 cubic centimeters.
4 fluidrachms	=	14.79 cubic centimeters.
5 fluidrachms	=	18.48 cubic centimeters.
6 fluidrachms	=	22.18 cubic centimeters.
7 fluidrachms	=	25.87 cubic centimeters.
1 fluidounce	=	29.57 cubic centimeters.
2 fluidounces	=	59.14 cubic centimeters.
3 fluidounces	=	88.72 cubic centimeters.
4 fluidounces	=	118.29 cubic centimeters.
5 fluidounces	=	147.86 cubic centimeters.
6 fluidounces	=	177.44 cubic centimeters.
7 fluidounces	=	207.01 cubic centimeters.
8 fluidounces	=	236.59 cubic centimeters.
1 pint	=	473.17 cubic centimeters.
1 quart	=	946.35 cubic centimeters.
1 gallon	=	3785.51 cubic centimeters.

Metric in United States Fluid Measure.

1 cubic centimeter	=	16.23 minims.
2 cubic centimeters	=	32.46 minims.
3 cubic centimeters	=	48.69 minims.
4 cubic centimeters	=	1.08 fluidrachms.
5 cubic centimeters	=	1.35 fluidrachms.
10 cubic centimeters	=	2.71 fluidrachms.
25 cubic centimeters	=	6.76 fluidrachms.
30 cubic centimeters	=	1.01 fluidounce.
50 cubic centimeters	=	1.69 fluidounces.
100 cubic centimeters	=	3.38 fluidounces.
500 cubic centimeters	=	16.90 fluidounces.
1000 cubic centimeters	=	33.81 fluidounces.

Troy Weight in Grammes.

1-100 grain	=	0.00065 gramme.
1-64 grain	=	0.00101 gramme.
1/8 grain	=	0.00810 gramme.
1/4 grain	=	0.01620 gramme.
1/2 grain	=	0.03240 gramme.
1 grain	=	0.0648 gramme.
1 1/2 grains	=	0.0972 gramme.
2 grains	=	0.1296 gramme.
5 grains	=	0.3239 gramme.
10 grains	=	0.6479 gramme.
20 grains	=	1.2960 grammes.
30 grains	=	1.9440 grammes.
60 grains (1 troy drachm)	=	3.8880 grammes.
2 drachms	=	7.7760 grammes.
4 drachms	=	15.5520 grammes.
1 ounce	=	31.1035 grammes.
2 ounces	=	62.201 grammes.
3 ounces	=	93.31 grammes.
4 ounces	=	124.41 grammes.
5 ounces	=	155.51 grammes.
6 ounces	=	186.62 grammes.
7 ounces	=	217.72 grammes.
8 ounces	=	248.82 grammes.
9 ounces	=	280.00 grammes.
10 ounces	=	311.03 grammes.
11 ounces	=	342.14 grammes.
12 ounces	=	373.24 grammes.
14 ounces	=	435.44 grammes.
16 ounces	=	497.65 grammes.
24 ounces	=	746.48 grammes.
48 ounces	=	1492.95 grammes.
100 ounces	=	3110.40 grammes.

U. S. in Metric Linear Measure.

1/4 inch	=	6.35 millimeters.
1/2 inch	=	12.70 millimeters.
3/4 inch	=	19.05 millimeters.
1 inch	=	2.54 centimeters.
2 inches	=	5.10 centimeters.
3 inches	=	7.62 centimeters.
4 inches	=	10.20 centimeters.
5 inches	=	12.70 centimeters.
6 inches	=	15.24 centimeters.
7 inches	=	17.78 centimeters.
8 inches	=	20.32 centimeters.
9 inches	=	22.86 centimeters.
10 inches	=	25.40 centimeters.
11 inches	=	27.94 centimeters.
12 inches	=	30.48 centimeters.

Metric Weights in Grains.

.050 gramme	=	.772 grain.
.100 gramme	=	1.543 grains.
.250 gramme	=	3.858 grains.
.500 gramme	=	7.716 grains.
1 gramme	=	15.432 grains.
2 grammes	=	30.865 grains.
3 grammes	=	46.297 grains.
4 grammes	=	61.729 grains.
5 grammes	=	77.162 grains.
10 grammes	=	154.323 grains.
25 grammes	=	385.809 grains.
50 grammes	=	771.617 grains.
100 grammes	=	1543.235 grains.
500 grammes	=	7716.174 grains.
1000 grammes	=	15432.350 grains.

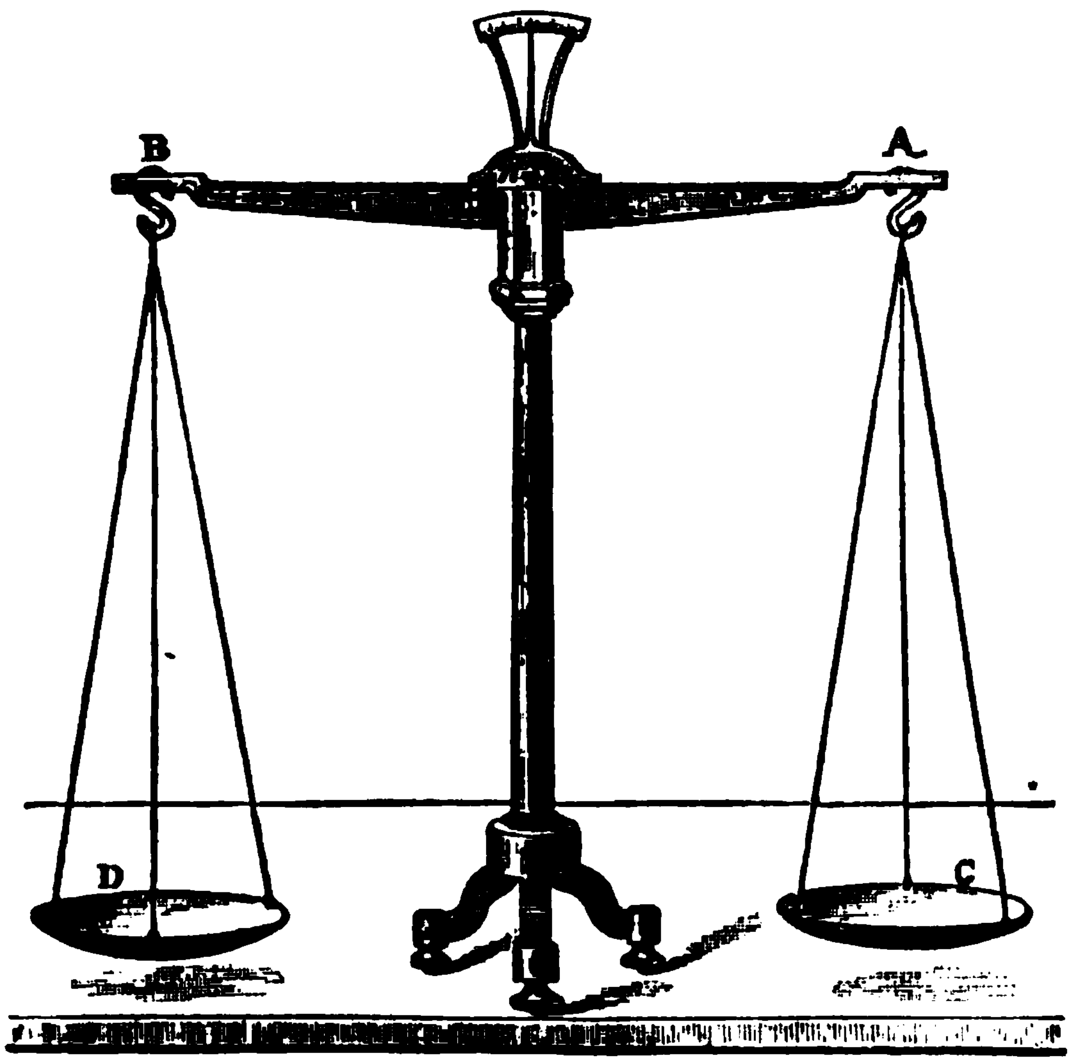
* *The Era Dose Book.*

WEIGHING AND MEASURING.

The earliest and most important operations the student is called upon to perform, are those of weighing and measuring. For this reason an accurate knowledge concerning the construction, use and application of the balance, weights and graduated vessels, is essentially necessary. The *balance* is any instrument based upon the principle of the equal or unequal lever, for determining the relative weights or masses of bodies. According to their construction, balances may be classified under various systems, as follows: 1. *Single beam, equal armed.* 2. *Single beam, unequal armed.* 3. *Double beam, unequal armed.* 4. *Compound lever balances.* 5. *Torsion system.*

Single Beam, Equal-Armed Balances.—A balance based upon this system, consists of an inflexible metallic beam (A B)

Fig. 7.



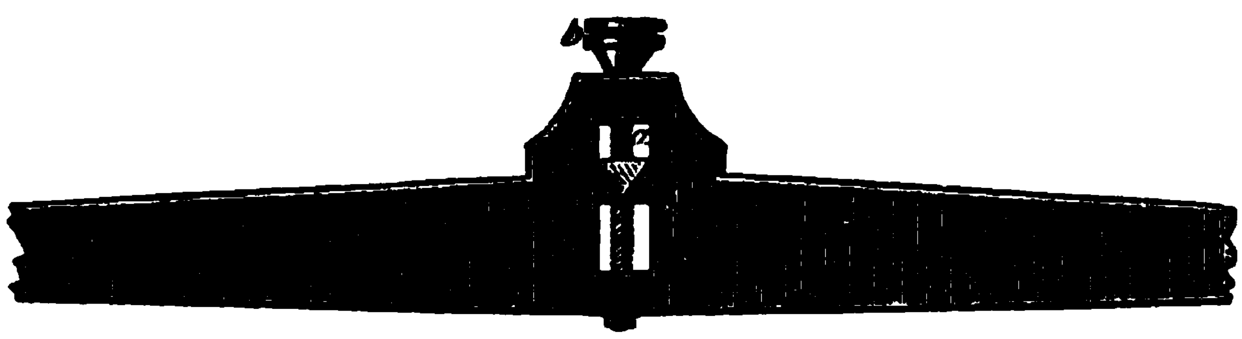
Balance.

supported horizontally, exactly over its center of gravity, by the fulcrum (n), which consists of a steel or agate prism, passing through the beam, and resting with its sharp edge upon two supports of steel or agate. At the extremities of this beam, pans are suspended in such a manner, that they may turn freely about axes passing through the extremities of the beam, and parallel to its axis of rotation. Thus we have three steel or agate edges; the middle one edge downward supporting the beam, and those at the extremities edge upward. On these are supported the agate or steel plates to which the pans are attached. Every equal-arm

balance possesses three important points,—the fulcrum (point of support) and the extremities of the two arms. At one extremity the force acts, and at the other the weight. The two arms must be *precisely equal in length*, the pans must also be of equal weight. To prove these two conditions the beam should be brought to a perfectly horizontal position, as shown by the indicator on the scale, by adding small weights or scraps of paper to the lighter pan, then place a weight upon one of the pans, and upon the other place small pieces of metal or shot until the indicator again shows a perfect state of equilibrium; then interchange the weights, and it will remain horizontal if the arms are equal. The center of gravity of the lever or beam should be as near as possible, yet immediately *below*, the fulcrum.

In Fig. 8 the effect of a change in the position of the center of gravity, is shown by raising or lowering the fulcrum *c* by means of the screw *b*. When the fulcrum is at the top of the groove, the center of gravity of the beam is *below* its edge, and the latter oscillates freely about a position of stable equilibrium. By lowering the fulcrum it may be brought to the exact center of gravity, where the beam no longer oscillates, but remains in equilibrium

FIG. 8.



Beam with Movable Fulcrum.

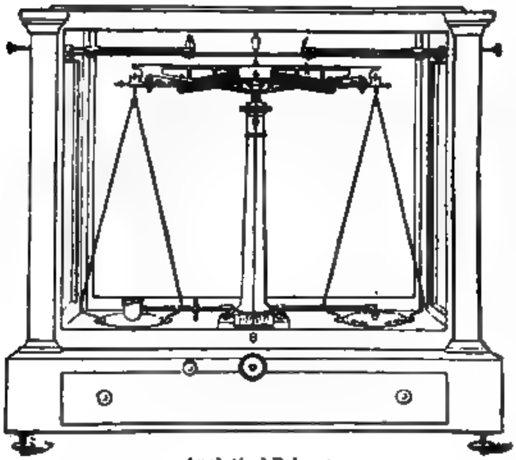
in all positions. When the fulcrum is brought *below* the center of gravity, the beam is in a state of unstable equilibrium and is overturned by the least displacement.

In balances for heavy weights, the center of gravity is placed lower than in delicate instruments, for by this arrangement the beam oscillates more readily, though it requires a larger weight to start it.

In a delicate or analytical balance, the axes of rotation are formed by agate knife edges bearing on polished agate plates. The beam is provided with three agate edges, the middle one, edge downward, serving as support of the beam itself, and those at the extremities with knife-edges upward, on which are supported the agate plates, to which the pans are attached. The beam is made as light as possible. There should also be a frame support to both the pans and beam, so that the beam may at any moment be released from contact with the agate plates, and the delicate knife-edges may not sustain injury from pressure or shocks. In order to define the *position* of the beam of the balance, a long metal pointer is fixed to it and oscillates with it. A small graduated index is fixed

near the base of the pillar and the motion of the beam is observed by noting the motion of the pointer along this index. When the balance is in good adjustment, the pointer should be opposite the central mark of the index, showing the beam to be horizontal. Levels should be placed in the glass case containing the balance, to show that it is in proper position, for a balance must always stand perfectly level. A balance is *delicate* when a very minute difference between the weights in the pans, causes a perceptible deflection of the pointer. To assist this, the beam should be as light as possible consistent with its rigidity. Since *friction* opposes the action of the forces, the number of points of friction should be as few as possible, and, in addition to this, the edges upon which the beam and pans are supported, should be made as hard as possible; hence agate is chosen with preference, as it is not liable to corrosion, like steel. In the more accurate balances,

FIG. 9.



Analytical Balance.

the beam is divided into ten parts with subdivisions, indicating milligrammes and tenths thereof. Above the beam is a brass rod, provided with a small hook, which can be moved back and forth from the outside. By its aid a small weight, in the form of a bent wire called a rider, usually weighing 1 milligramme, may be placed on any of the divisions of the beam. By means of this, minute weighings may be made where larger weights are not suitable. In weighing a body on an analytical balance, place it clean and dry upon one pan, then place a corresponding weight on the other pan, and slowly remove the frame supports of the arm and pans by means of the key; if on so doing, the indicator shows that one

FIG. 10.

Prescription Balance.

pan is heavier than the other, restore the supports and change the weights accordingly, continuing this until the pointer swings equally about the center point, or remains stationary at the center.

What has been said about the analytical balance also holds good for the prescription balance.

MAXIMS.

Never load or unload a pan when the beam is rotating, but first arrest the scale-pans.

Weights should be placed and removed by means of a pair of ivory-pointed pincers.

Loads and weights must be placed on the pan *carefully*, and not suddenly.

In weighing powders, employ watch-glasses, which should have been carefully adjusted to equilibrium.

No fuming liquids should be weighed on a delicate balance, unless in a properly closed vessel.

Each object, before being weighed, should be wiped perfectly dry.

Before attempting to load any balance, first see that the beam moves freely about, and finally rests in a state of equilibrium.

An analytical or prescription balance should be kept in a dry and clean room, where there is but little variation of temperature, and should be enclosed in a suitable glass case.

A balance should never be overloaded. Each one has its safe limit of capacity, and suffers accordingly when overtaxed.

It is customary to place a wide-mouthed flask or capsule containing sulphuric acid or calcium chloride inside of the balance case, to keep the air as dry as possible.

Hand Scales.—This form of scale consists of a brass beam

FIG. 11.

Hand Scales.

FIG. 12.

Proper Way of Holding Hand Scales.

with a central knife edge, which is enclosed, to protect it from dust and corrosion as much as possible. The two pans are of horn supported by silken cord from wire hooks, which are hung from perforations in each end of the beam; a pointer, perpendicular to

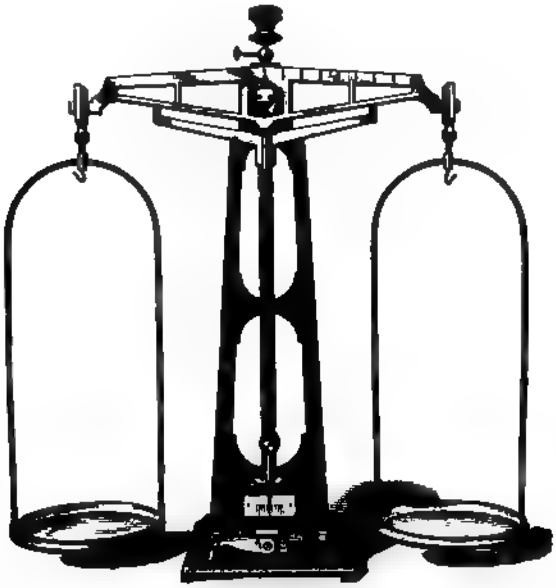
the beam, oscillates between the supporting arms. In weighing, the scales should be grasped by the hook above (Fig. 12), between the thumb and fore-finger, the equilibrium of the beam being preserved by holding the fourth and fifth fingers on either side. While the pans are loaded, any slight deviation to either side is felt at once by the indicator oscillating to the right or left; before the material is removed, the balance should be allowed to swing free. These hand balances, with care, can be used for weighing quantities as low as one centigramme. They should not be employed for weighing alkaloids or potent drugs. For this purpose, only the sensitive prescription balance (Fig. 10) should be employed.

FIG. 13.

Army Prescription Scales.

A similar form called the Army Balance (Fig. 13), in which the beam is supported upon a rigid pillar, is very convenient for prescription use, but inasmuch as they are made of brass and all the metal bearings are exposed, they soon corrode; the sensitive parts become coated with dust, and the balance becomes worthless. Such a balance should be kept under a glass cover protected from moist air and dust.

FIG. 14.



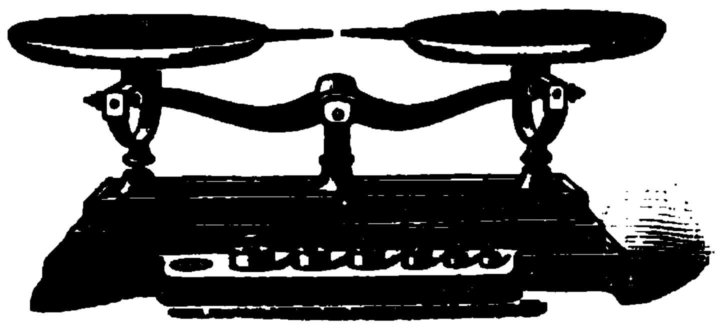
Counter Balance.

Fig. 14 illustrates a form of Counter Balance, which is very con-

venient and quite accurate. The brass parts should be lacquered to prevent rusting.

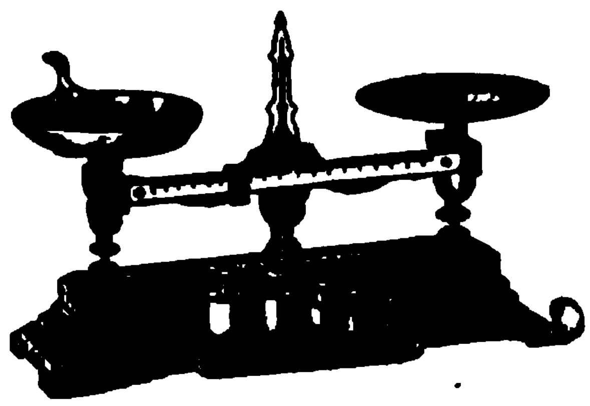
Figs. 15, 16 illustrate two forms of the counter scale, in which the pans are above the beams; the one (Fig. 16) is provided with

FIG. 15.



Counter Balance (Laboratory).

FIG. 16.

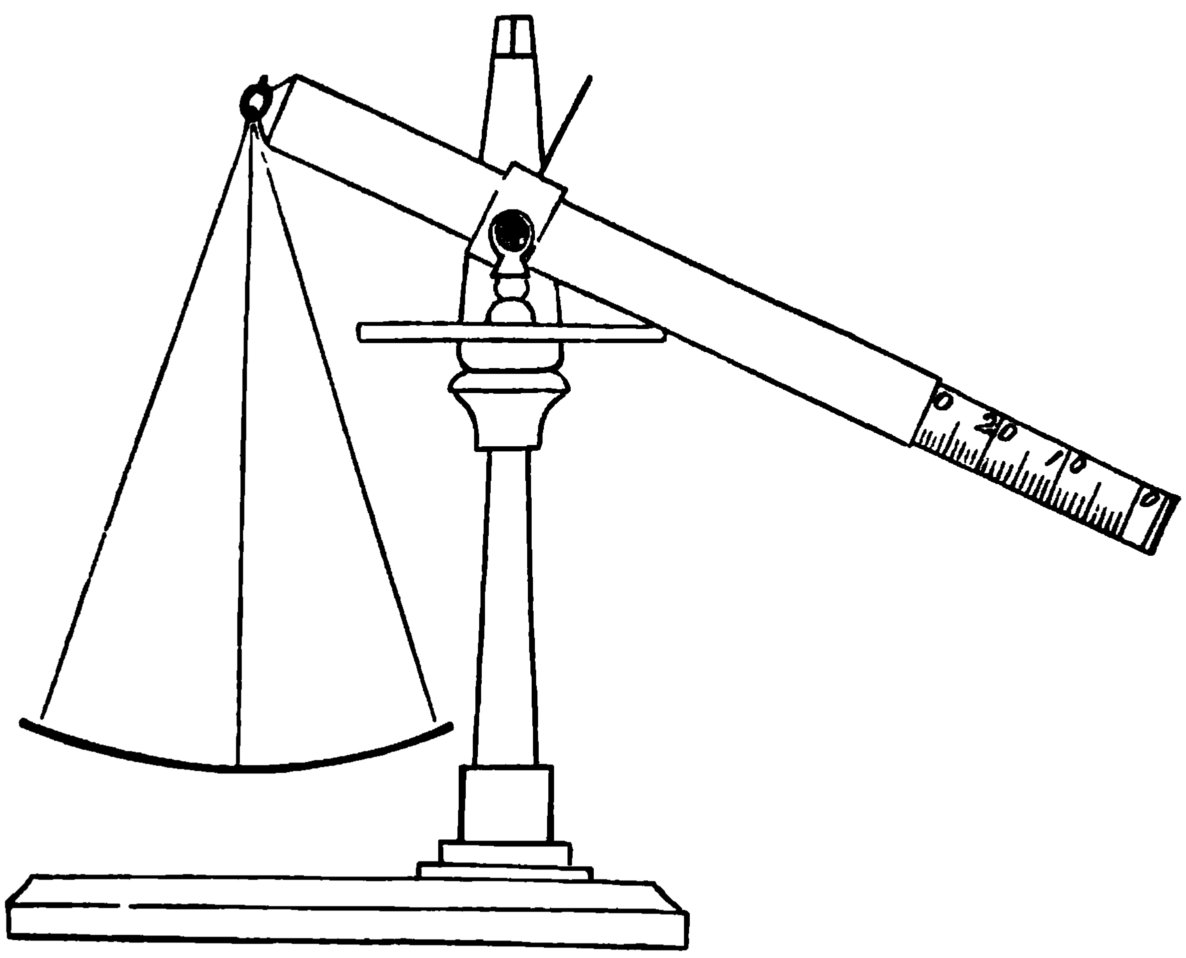


Counter Balance (Dispensing).

a graduated parallel bar, upon which a poise slides back and forth. This is very useful for counterpoise weighing.

SINGLE BEAM, BUT UNEQUAL-ARMED LEVER BALANCES.—The simplest form of these is the old steelyard or Roman balance, in which only the shorter arm bears a pan; the longer arm, by

FIG. 17.



Gorham Dispensing Balance.

means of notches, is divided into a scale, over which slides a counterpoise weight. An embodiment of this same idea is the Gorham dispensing balance (Fig. 17) in which a rod or tube, sliding within a tubular arm, replaces the external movable weight. The same principle, is shown in the Fairbank's druggists' scale, in which the inequality in the length of a beam permits the use

of a sliding counterpoise weight along the longer graduated arm. This possesses the advantage that it dispenses with the use of small weights. Fig. 19 illustrates a new form of Double Beam and Unequal-Armed Balance, which is specially adapted for weighing liquids. It will weigh liquids up to ten kilos and over with an accuracy, that cannot be approached by ordinary methods. The scale is provided with two weighing beams and sliding poises. One of these is divided into one hundred parts, each part representing one gramme; the other beam is divided into ten parts, each representing one hundred grammes. A bar with a sliding poise is placed under and between the weighing beams, for the purpose of balancing the empty bottle or container, which is quickly done by sliding the poise along the bar until equilibrium is secured.

FIG. 18.

Fairbank's Druggists' Scale.

FIG. 19.

Balance for Weighing Solutions.

A convenient form of vest-pocket prescription scale based on this principle, is that made by Shepard & Dudley, of New York.

FIG. 20.

Physician's Vest-pocket Scale.

It is very convenient for physicians, and answers very well as a substitute for the horn-pan balance.

COMPOUND LEVER BALANCES.—This system is based on the old Robervahl balance, in which the pans are *above* a system of

levers (which is usually concealed in a box). In this system, practical convenience and rapidity are gained at the expense of accuracy. The great objection to this form is that it will never vibrate as smoothly as the other forms of balances, because of the great friction in the numerous pivots. The Counter Scale, illus-

FIG. 21.

Counter Scale.

trated (Fig. 21), is constructed upon this principle, having a large number of points of friction.

The Box Prescription Scale (Fig. 22) is constructed upon this same principle. These scales are, indeed, very convenient, being enclosed and protected from dust and air. They do not, however, long retain their accuracy, hence are not well adapted for prescription use.

FIG. 22.

Box Prescription Scale.

TORSION SYSTEM.

The defects of the Compound Lever Balance have been overcome to a great extent by the Springer Torsion Balance, in which the knife edge, upon which the old form of balance depends, is replaced by thin steel springs, stretched tightly between bearings, the center of the beam being fastened to the center of the strained spring and at right angles to it. Under this condition, the beam will vibrate precisely as an ordinary beam, balanced upon knife edges. Torsional resistance tends to hold the beam in a horizontal position. This is overcome, however, by placing an adjustable weight (supported on a perpendicular rod attached to the beam) just over the center of gravity; this has the tendency to produce unstable equilibrium, and induces vibration to either side. This weight (ball) can be raised or lowered on the perpendicular rod, thereby regulating sensitiveness (Fig. 23); it is now replaced by two smaller weights, one on either side of the central frame (Fig. 24). From the illustra-

tions, the balance will be seen to consist of two beams (upper and lower), supported on three frames of like size. Over each of these,

FIG. 23.

Torsion Counter Scale.

FIG. 24.

Torsion Counter Scale.

a steel wire (band) is stretched, which forms the support for the beam.

Figs. 23 and 24 illustrate two forms of counter scale which are sensitive to $\frac{1}{2}$ grain, and will carry 20 pounds without injury. The one shown in figure 24 is provided with a triple graduated beam with sliding weight, inside the glass case; this beam is graduated in the Metric, Troy and Avoirdupois systems. Fig. 25 illustrates the prescription balance, enclosed in a glass case with rider and adjustment, by means of which, from $\frac{1}{8}$ grain to 8 ounces can be weighed with the upper half of the graduated beam, and from $\frac{1}{2}$ centigramme to 5 decigrammes with the lower half. The balance is said to be sensitive to $\frac{1}{64}$ of a grain.

FIG. 25.

Torsion Prescription Scale.

FIG. 26.

Triple Graduated Beam.

The principal advantage possessed by this balance, is its freedom from friction; hence its greater accuracy; the only objection it is open to, is the unavoidable rigidity of the elastic wires.

Care of the Balance.—The Counter scale should be placed on a firm, level surface, where it will not be exposed to any jarring or corrosive vapors. It should be frequently cleansed with soft leather, care being taken to remove particles of dust that may collect on any exposed points; when used, the pans should always be covered with counterbalanced pieces of glazed paper, to avoid the adhering of moist powders, which, in time, would cause corrosion; when the pans are to be cleaned, they are best washed with warm soap-suds and well dried. *Never scour* the pans or any of the working parts of a balance.

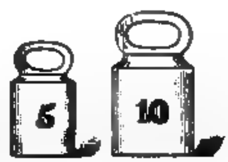
WEIGHTS.

Weights are small pieces of metal (or glass, etc.) so adjusted as to correspond with the legal standards. Commercial weights are

Fig. 27.

Avoirdupois Iron Weights.

Fig. 28.



Metric Iron Weights.

Fig. 29.

Cup Weights (Troy).

of iron, brass, or bronze. Analytical weights are made of brass, and should be plated with either gold or platinum, to protect them from corrosion or oxidation, which usually takes place in brass or other metals. Those of smaller denomination, from 0.5 Gm. down, are usually made of aluminum or platinum. Weights of agate are also to be had; the value of these is at once apparent.

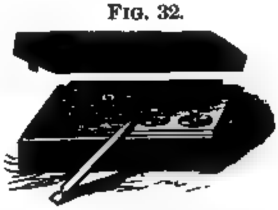
Fig. 30.

Block Weights.

Fig. 31.

Prescription Weights (Metric).

Fig. 32.



Analytical Weights.

The commercial weights are usually circular and flat; the older styles were made cup-shaped, fitting one into the other. These forms will answer very well for commercial purposes, for weighing by the pound, but will never do for weighing small amounts, where any degree of accuracy is required, since, owing to the numerous cavities, filth is apt to collect in them. It is

always preferable to buy the so-called *Block-weights*, lacquered. These are conveniently arranged in regular order in a wooden block, thus enabling the user readily to find any desired weight; also, they do not receive the same rough usage and wear in hand-

FIGS. 33, 34.

Aluminum Wire Weights. Aluminum Grain Weights.

ling, as the cup-shaped form. Every apothecary should be provided with a set of *accurate* prescription weights (Fig. 31); these usually come in wooden blocks with hinged covers, and are generally made of brass, except those of denominations from 10 grains,

FIGS. 35, 36, 37, 38.

Apothecaries' Coin Weights. Brass-foil Grain Weights.

Brass Metric Weights.

Aluminum Wire Weights (Metric). Aluminum Metric Weights.

or from 500 milligrammes down, which are usually made of aluminum. Each box of weights should be provided with a pair of smooth-pointed pincers (preferably tipped with ivory), for the purpose of handling the weights.

Never handle prescription or analytical weights with the fingers.

The apothecaries' coin brass weights, as usually employed throughout the country, are very inaccurate, owing to the careless, cheap manufacture, and constant rough handling and corrosion. The brass-foil grain weights are subject to the same objection; the best form of grain weights are those of aluminum wire, their angular form rendering them easily distinguishable; these do not corrode.

MEASURING FLUIDS.

For the measurement of fluids, the apothecary employs almost altogether the glass graduate. This has entirely supplanted the old form of porcelain measuring cup, which being graduated inside, made it very difficult to measure off fluids with any degree of accuracy. Glass graduates are now furnished in various forms and designs: the tumbler-shaped is generally preferred, because of the ease with which it is cleaned. These are recommended for measuring quantities over one fluidounce (30 Cc.). Because of its smaller diameter near the bottom, the conical form admits the measuring of the smaller quantities with more accuracy; however, some forms of these are not as easily cleansed as those of wider bottom. Lately, an improvement has been made by graduating measures doubly; upon one side, the U. S. fluid measures are marked, while on the other,

FIG. 39.

Porcelain Measuring Cup.

FIG. 40. FIG. 41. FIG. 42.

Tumbler-shaped Graduate. "Acme" Graduate. Conical-shaped Graduate.

measures of the metric system are indicated. For the accurate measurement of smaller volumes, small graduated cylinders are preferably employed. These are graduated into fluidrachms and minims, or cubic centimeters and fractions thereof.

Great care should be exercised in the selection of graduates, and only measures of guaranteed accuracy, or such which have been verified, should be accepted. It is advisable to select measures in which the graduating mark passes entirely around the graduate, which assists in securing the level of the fluid with more accuracy.

We cannot expect to measure accurately, if the graduate be held at an angle, instead of perpendicularly, as it should be. The measure should be grasped just above the base, between the thumb and forefinger, the weight being supported upon the other three fingers; and it should be held so that the rings of graduation are in a perfectly *horizontal* plane.

In order to test the accuracy of a graduate or measuring cylinder, it should be carefully counterbalanced on a pair of sensitive scales, then the requisite weight of distilled water corresponding to a given volume at 60° F. poured in, for which purpose the fluidounce may be reckoned equal to 455.69 grains, or the cubic centimeter equal to 1 gramme. Then the measure should be

FIG. 43. FIG. 44. FIG. 45.

Cubic Centimeter and Minim Measures.

placed on a perfectly level surface, and the height of the water as compared with the marks of the measure carefully noted.

For measuring very small volumes, such as 20 minims (or 1 Cc.) or less, the minim graduate should not be used, since there is a considerable loss of fluid in draining off, which adheres to the side of the measure. If the graduate can be rinsed out with other fluids subsequently entering the same mixture, the loss is avoided.

Where such is not the case, recourse is had to the measuring *pipette*. See page 165.

These pipettes are constructed of various capacities; the larger sizes, which usually have a bulb, hold 5, 10, 20, and 50 cubic centimeters respectively; the smaller, which are plain, graduated tubes, hold one fluidrachm, graduated into fractions and minims, or one cubic centimeter divided into tenths.

CHAPTER II.

SPECIFIC GRAVITY. DENSITY.*

Specific Gravity may be generally defined, as the weight of a body compared with the weight of an equal volume of some standard substance. For liquids and solids, the standard chosen is distilled water at 4° C. (39° F.). Specific gravity expresses a relative, and not an absolute value. It states how many times lighter or heavier the known volume of a body is, than the same volume of another, which is taken as a standard. When we say that the specific gravity of mercury is 13.5, we mean that 1 cubic centimeter, or 1 fluid ounce, or 1 liter, etc., of it is 13.5 times as heavy as the same volume of water. A knowledge of specific gravity often assists qualitative tests in the identification of minerals, metals, salts, organic substances, fluids, etc. It often enables us to ascertain their purity, as the presence of foreign bodies exerts an influence upon their specific gravities, causing them to be raised or lowered. It enables us to tell at once what any given volume of a liquid should weigh, or conversely, what volume will be required to contain any given weight. From the specific gravity we can readily calculate the percentage strength of many fluids, such as acids, alkaline solutions, solutions of salts, etc. From the specific gravity of urine, the physician diagnoses certain diseases.

Since all bodies expand or contract by change of temperature, it is necessary carefully to observe this when determining specific gravities, for 1 Cc. of water at the temperature of 4° C. or 39° F. (its greatest density) weighs 1 gramme, while the same volume at a temperature of 15.5° C. or 60° F. weighs 0.999 Gm. The standard volume of water for unity (1000) used for comparison, varies in different nations, being on the Continent of Europe generally taken at its maximum density (4° C.), in Great Britain at 16.6° C., and in the United States at 15.5° C., together with the Pharmacopœia standard of 15° C.

For general purposes, we express the value of any specific

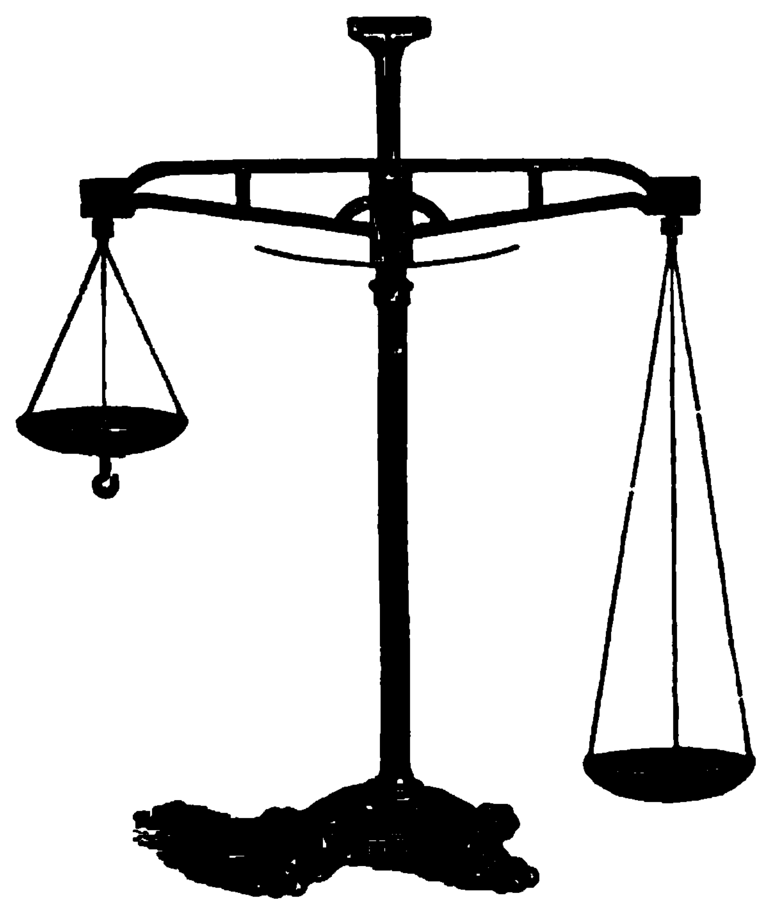
* On account of its more general use the term specific gravity is retained, although "density" is more accurate. The former involves the consideration of the action of the earth's attraction on the body to be examined. This attraction is not uniform over the whole of the earth's surface, being 1 to 2 per cent. less at the Equator than at the Poles. Practically, no difficulty arises from this fact, for we generally take the specific gravity or density of a body by means of a balance, in which case the relationship between object weighed and the weights, remains unchanged. When we employ the Jolly spring balance (Fig. 61), the above difficulty arises, in which the object is less attracted at the Equator, than at other parts of the earth's surface.

gravity to three places of decimals, which usually involves more or less error in the third place; however, where greater accuracy is required, it is expressed to four, five, or more decimal places, the necessary corrections being applied to eliminate errors as far as possible.

SPECIFIC GRAVITY OF SOLIDS.

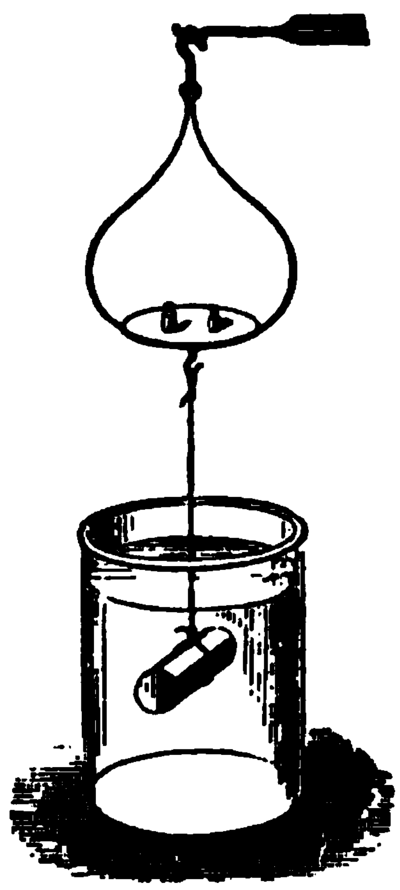
The methods for the determination of the specific gravity of solids depend on the principle discovered by Archimedes, that when a solid is immersed in water, it loses in weight an amount equal to the volume of water it displaces. The solid whose specific gravity is to be taken—assuming it to be insoluble in water—is well cleansed and freed from adhering moisture, then accurately weighed (denote this weight by x); then, by means of a horse-hair, silk thread, or fine platinum wire, it is suspended

FIG. 46.



Hydrostatic Balance.

FIG. 47.



Immersion of Solid.

from one arm or pan of a balance, so that it is entirely submerged, and does not come in contact with the sides of the vessel holding the water (Fig. 47); its weight is then noted (denote by y). A thermometer placed in the water indicates the temperature (t). The specific gravity is then found by the rule (1):—"*Divide the weight of the body in air by its loss of weight in water: the quotient will be the specific gravity.*" That is, the specific gravity at the temperature t° is equal to $\frac{x}{x-y}$.

Example:—

A piece of metal weighs in air, ...	40 grammes.
Immersed in distilled water (60° F.) it weighs, . .	35 "
Loss of weight in water, ...	5 "

Then its specific gravity at 60° F., ... $= \frac{40}{40-35} = \frac{40}{5} = 8.00.$

This determination may be carried out more expeditiously by means of the hydrostatic balance (Fig. 46), which consists of two counterbalanced pans (hung at unequal heights); under the shorter one is placed a hook, from which the body is suspended. The latter is first weighed alone in the usual manner in air, then immersed in the vessel of water at the proper temperature; this causes the short pan to become lighter. Weights are then added until the balance gains its equilibrium; the weight thus placed in the short pan to accomplish this, constitutes the loss of weight in water.

Displacement in Graduated Cylinder.—Into a cylinder graduated in cubic centimeters, or better, fractions thereof, water of the proper temperature is poured, until it reaches some definite mark on the graduated scale. The body previously weighed in air is now dropped into it, which causes the level of water to rise, and thereby shows the exact bulk of water displaced by the solid; this is equivalent to the loss of weight in water, since each cubic centimeter of water weighs one gramme. Then apply the rule:—

Example:—

A piece of metal weighs, ...	3.0 grammes.
The bulk of water displaced, ...	1.5 cubic centimeters = 1.5 Gm.

The specific gravity will be $\frac{3.0}{1.5} = 2.0.$

Separation of Different Insoluble Bodies by Means of their Specific Gravities.—This method is employed mainly by mineralogists for separating various minerals from crushed rock ore. Dense liquids of known specific gravity are employed, in which these solids will just float. For substances lighter than water, dilute spirits may be used; for those heavier than water, solutions of common salt, solution of mercuric nitrate, solution of potassio-mercuric iodide (3.196 sp. gr.), ethylene bromide, etc., are used. All that is necessary, is that the density of the liquid be known, it being presumed that the solid is not acted upon by the fluid.

Specific Gravity of Insoluble Powders Heavier than Water.—Weigh off a portion of the powder, then introduce it into a counterpoised specific gravity bottle, which is so constructed as to hold a known weight (1000 grains, etc.,) of distilled water. Some water is poured in, and the contents gently rotated so as to remove any air bubbles that may adhere to the powder, then the flask is filled to the mark indicating its capacity, and weighed. From the weight of the powder in the air,

plus the known weight of water which the bottle will hold, *subtract* the weight obtained in the second operation. The remainder represents the weight of water displaced by the powder. Then apply the rule:—

Example:—

10 grammes of a powder is taken, poured into a counterpoised specific gravity bottle of 100 grammes' capacity, which, when filled with water, weighs 108.8 Gm.

10 grammes + 100 grammes	=	110.0	grammes.
Weight of flask containing water and powder, ...	=	108.8	"
Difference or weight of water displaced		1.2	"

Therefore, the weight in air (10 grammes) divided by the loss of weight in water (1.2 grammes), gives us 8.33 as the specific gravity of the powder.

This method may be employed for solids, provided they are in pieces of such size as to admit of being placed in the specific gravity bottle.

SPECIFIC GRAVITY OF SOLIDS INSOLUBLE IN, BUT LIGHTER THAN WATER.*—Inasmuch as such a body floats on the surface of water, it necessarily follows, that we must attach it to a heavier body in order to secure the submersion of both. The loss of weight of the heavy body in water must be known, and when this is deducted from the loss of weight of both together, the difference will give the amount of water displaced by the light body alone. The light body is first weighed in air, it is then attached to a sinker (a piece of lead or iron) and again weighed; then both are suspended by a thread under the surface of distilled water and their combined weight in water noted. The light body is detached and the weight of the sinker alone in water is ascertained. The loss of weight of the sinker alone in water is now deducted from the loss of both; this gives the loss of weight of the light body; then apply the rule.—

Example:—

A piece of brass weighs 5 grammes; in water it weighs 4.4 grammes.

A piece of wax weighs in air 13.37 grammes; when attached to sinker, both weigh 3.88 grammes in water:—

Weight of brass in air, .	5.00	grammes.	Wax weighs in air, . .	13.37	grammes.
" " " " water,	4.40	"	Brass " " " . .	5.00	"
Loss of weight of brass in water, ...	0.60	"	Sum of both, ...	18.37	"
			Both weigh in water, . .	3.88	"
			Both lose in water, . .	14.49	"

Loss of weight of both in water, ...	14.49	grammes.
" " " " brass " "	0.60	"
" " " " wax alone, ...	13.89	"

$$\text{Then}\quad \frac{\text{weight of wax in air,}}{\text{loss of weight in water,}} = \frac{13.37}{13.89} = 0.962 \text{ specific gravity.}$$

* The method of Symons (*Phar. Jour. Trans.*, (3) XIX, 206) may be employed. He fixes an inverted funnel under one scale-pan, attaches a ten-gramme weight to it, and restores equilibrium. The previously weighed light solid is now held under water until air-bubbles are removed, and then placed under the funnel; the weight lost will represent the volume of the solid, or, in other words, will be the weight of a volume of water equal to the volume of the solid.

SPECIFIC GRAVITY OF SOLIDS SOLUBLE IN WATER.—We proceed exactly in the same manner as in the case of solids heavier but insoluble in water; but instead of water, we employ some liquid in which the body is not soluble. The liquids usually selected for this purpose are the oils of turpentine, olive, or almond. The specific gravity of the body having been obtained just as if water had been used, the result is multiplied by the known specific gravity of the oil employed.

Example :—

A crystal of citric acid weighs 10.0 grammes; when immersed in Oil of Turpentine it weighed 4.8 grammes. Then :—

The weight of the citric acid in air was, ...	10.0	grammes.
" " " " " " " oil of turpentine, . . .	4.8	"
Loss of weight in turpentine, ...	5.2	"

then dividing 10 by 5.2 we get 1.92, the specific gravity of citric acid referred to oil of turpentine as standard, and multiplying this by 0.870, the specific gravity of oil of turpentine, we obtain 1.67 the specific gravity of the sample of citric acid, as referred to the usual standard, viz.: water.

SPECIFIC GRAVITY OF LIQUIDS.—METHODS OF DETERMINING.

(*a*) By means of the Pycnometer.
(*b*) " " " Hydrometer.
(*c*) " " " Specific Gravity Balance.
(*d*) " " " Sprengel's Specific Gravity Tube.
(*e*) " " " Weight of given Volumes.
(*f*) " " " Lovi's Specific Gravity Beads.

(*a*) DETERMINATION OF THE SPECIFIC GRAVITY OF LIQUIDS BY MEANS OF THE PYCNOMETER.—For ascertaining the specific gravity of a fluid we employ the *Pycnometer* or specific gravity bottle, which, in its simplest form, is a small, light glass flask with a long and narrow neck.* The flask, after being counterbalanced, is filled with any convenient amount of distilled water at the proper temperature, the height of the fluid marked, and its weight noted. These flasks are usually constructed to hold 25, 50, or 100 grammes, or 1000 grains of distilled water at 15.5° C. (60° F.). The bottle when emptied and dried, is filled to the mark with the liquid to be tested and weighed. The weight found bears a simple ratio to the specific gravity. Thus if the flask holds 100 grammes of distilled water at 15.5° C., when filled with ether, it will hold 72.5 grammes, and with glycerin, 125 grammes. The specific gravities of these two liquids are, then, 0.725 and 1.250, respectively,

FIG. 48.

Pycnometer.

* Some of the older forms are quite short, as shown in figure 48.

obtained by dividing 72.5 and 125 by 100. Any ordinary vial may be converted into a specific gravity bottle, by selecting one as light as possible, which will hold either 50 or 100 grammes of water. The distilled water is accurately weighed into the vial, and the exact height of the water is indicated by a mark (scratch) on the neck. An exact counterpoise is prepared for the empty flask. When used, the flask is filled to the mark with the liquid at the proper temperature, and its weight is divided by 50 or 100 as the case may be. Supposing, for example, that, when filled to the 50 cubic centimeter mark with sulphuric acid, it weighed 92.15 grammes, then $\frac{92.15}{50.00} = 1.843$, the specific gravity of the acid.*

FIG. 49.

Pycnometer with Thermometer.

Pycnometers are either sold with a brass counterpoise or their exact weight is etched upon the bottle. Before the pycnometer is used, it should be first well rinsed with water, then with alcohol, and dried. After bringing the liquid to the proper temperature, by placing the vessel containing it in a bath of known temperature, the flask is filled nearly to the top of the neck, and the stopper is inserted, care being taken to avoid the retention of air bubbles. The superfluous fluid displaced by the stopper is then removed, and the flask then wiped perfectly dry and clean, and weighed. This form of specific gravity bottle has the objection that the temperature cannot be carefully observed, which renders it unsuitable for very accurate work.

A better form of specific gravity bottle (Fig. 49) is that in which the stopper consists of a thermometer. The liquid is introduced in the side tubulure until it reaches the mark at m. Care should be taken that no air bubbles be allowed to collect around the neck at h.

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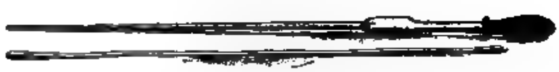
* It should be borne in mind that the *temperature* of *observation* should always be stated, and also that at which the *standard* was determined. To illustrate the importance of this Dr. Wright (*Jour. Soc. Chem. Ind.*, xi, -298) cites the following:—"A sample of oil at 20° C. is stated by one observer to have the specific gravity of 0.92475 referred to water at 4° C., another the specific gravity of 0.92560 referred to water at 15.5° C., and the third the specific gravity of 0.92635 referred to water at 20° C." from appearance, these figures do not seem concordant, but if we remember that when reduced to "weight per cubic centimeter," it will be seen that they are identical. Taking the specific gravity of water at 4° C. as 1.000, then at 15.5° C. it is 0.99908, and at 20° C. it is 0.99827. hence

"$0.92475 \times 1.0000 = 0.92475.$
$0.92560 \times 0.99908 = 0.92475.$
$0.92635 \times 0.99827 = 0.92475.$"

For the various corrections to secure accuracy in taking specific gravities, see the above-cited reference.

Another form is that devised by Dr. Squibb (Fig. 50), in which the neck of the bottle is lengthened, so that it will permit the bottle to hold the volume of water at any temperature between 4° C. and 25° C., thus adapting it to all standards in use. The capacity and tare is indicated on each bottle. A leaden collar is placed over the neck to keep it in position in the bath in which it is placed.

FIG. 50.



Squibb's Pycnometer.

(*b*) DETERMINATION OF THE SPECIFIC GRAVITY OF LIQUIDS BY MEANS OF THE HYDROMETER OR AREOMETER.—This instrument depends for its use on the fact that, when a solid is immersed in a liquid specifically heavier, it will sink until it reaches a point where the weight of the liquid displaced is equal to the weight of

the floating body. Hydrometers are long glass tubes with two bulbs blown at one end. The lower (smaller) bulb is weighted with sufficient mercury or shot to cause the tube to float upright, the upper (larger) bulb is to impart buoyancy.

Hydrometers are divided into two classes, the "*Weighing Hydrometers*" and "*Scale Hydrometers.*"

FIGS. 51, 52.

The weighing areometer or hydrometer of constant immersion but variable weight is so called because it is always immersed to the *same* mark, but requires *different* weights to effect this. The first of these was constructed by Fahrenheit; the same principle, however, is followed in

FIG. 53.

Nicholson's Hydrometer.

a

b

Hydrometers.
a. Weighing Hydrometer.
b. Scale Hydrometer.

that of Nicholson's hydrometer (Fig. 53), which consists of a hollow metal cylinder B with a cone C, weighted so that the cylinder may float vertical. At the top is a stem terminated by a pan, in which the substance whose specific gravity is to be determined is placed. When floated, the apparatus stands partly out of the liquid, hence, the first step would be to ascertain what weight is necessary to cause it to sink to the standard point *o*; let this weight be 100 grammes. Let us assume that we desire to ascertain the specific gravity of a piece of metal; the weights are removed from the pan, and replaced by the sample; weights are now added, until the instrument again sinks to *o*; in order to accomplish this, we have added 44 grammes; then the actual

weight of the piece of metal would be the difference between 100 grammes and 44 grammes, which is 56 grammes. Thus far, we have ascertained the actual weight of the metal; it is next necessary for us to ascertain its loss in water, or the weight of an equal volume of water. With this object in view, we place it in the lower cone C, at *m;* the instrument does not sink to *o*, for the metal, by immersion, has lost a part of its weight equal to that of the water displaced. Weights are added to the upper pan until the hydrometer sinks again to *o*; this being 27.5 grammes, is the weight of water displaced; then on dividing its actual weight (in air), by its loss in water $\frac{56}{27.5}$ we obtain 2.03 as its specific gravity. Bodies lighter than water are placed in the covered cup, thus securing immersion.

Rousseau's Densimeter.—This instrument (Fig. 54) is of use in ascertaining the specific gravity of liquids where only a small amount is available. The cup above is graduated to hold 1 cubic centimeter. When empty, the instrument sinks in distilled water to the point B; when the cup is filled with distilled water (1 Cc.), the point to which it sinks is marked as 20; then, the interval between 0 and 20, on the stem, is divided into 20 equal parts, the graduation being continued to the top, each division representing 0.05 gramme. *Example:* Supposing that the cup is filled with oil of neroli, the densimeter will sink to the mark 17.5; hence the specific gravity of the oil of neroli would be $0.05 \times 17.5 = 0.875$. Neither of these instruments gives such accurate results as the specific gravity bottle.

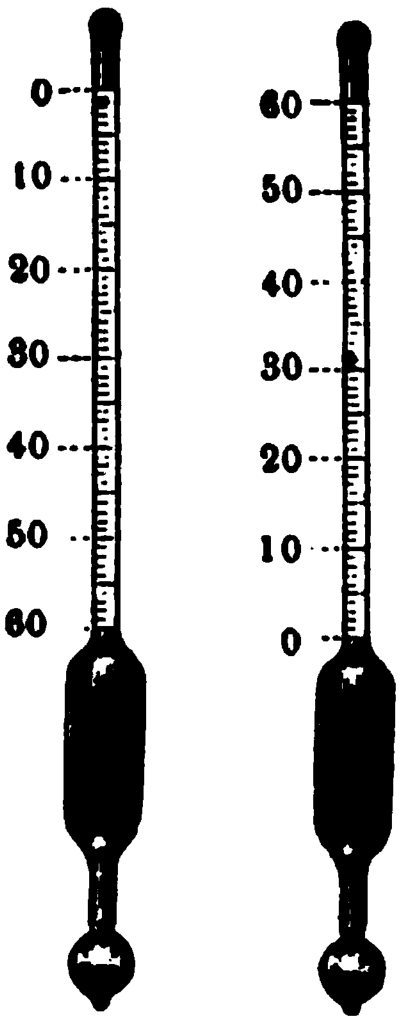
FIG. 54.

Rousseau's Densimeter.

Scale Areometers or Hydrometers of Variable Immersion but Constant Weight.—These are divided into different classes, according to their uses, being designated as *Alcoholometers, Salimeters, Lactometers, Acidometers, Saccharometers, Urinometers,* etc. There are two systems of these; in the one, the specific gravity is indicated directly on the scale; in the other (that of Baumé, Cartier, Twaddell, Tralles, etc.) an empirical scale is employed which may be reduced to specific gravity by referring to tables constructed for this purpose. The most important of these instruments is that of Baumé, under which name two distinct instruments are used. One of these is used for determining the densities of liquids heavier than water, such as acids, alkaline solutions, syrups, glycerin, milk, etc.; the other for liquids lighter than water, as alcohols, ethers, most volatile oils, etc. In the former (Fig. 55), for liquids heavier than water, the zero mark is obtained by placing it in distilled water; another mark is made at the place to which it sinks by floating it in a 15 per cent. solution of common salt.

The space between these two marks is then divided into 15 equal parts, the graduation being continued to 60° below. For liquids lighter than water (Fig. 56), zero is the point designated to which it sinks when placed in a 10 per cent. salt solution, and 10° the point to which it sinks in distilled water; the distance between these is divided into 10 equal parts, the scale being extended up to 60°.*

FIG. 55. FIG. 56.



Baumé's Hydrometers.

Twaddell's areometer, for liquids heavier than water, is common in England. It is so graduated that the reading multiplied by 5 and added to 1000 gives the specific gravity: thus, 15° Twaddell is equal to specific gravity 1.075. Alcoholometers are hydrometers for ascertaining the percentage strength of alcoholic liquids. They are often so constructed as to combine a thermometer, the mercury in the lower bulb answering for the bulb of the thermometer.

The *Tralles hydrometer* is an alcoholometer having a centesimal scale, each division corresponding to a certain per cent. of absolute alcohol, by volume. Tables giving the equivalents may be found in the Dispensatories and other works of reference.

Sikes' hydrometer is used in England by the Excise Revenue officers for ascertaining the percentage strength of spirituous liquors. The instrument is of brass, the stem being graduated from 0 to 10, and a set of nine weights to place beneath the bulb. On noting the temperature, the weight employed, and

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* TABLES OF DEGREE BAUMÉ. 15° C.

FOR LIQUIDS HEAVIER THAN WATER.

Baumé.	*Specific Gravity.*
0°	1.000
5°	1.036
10°	1.075
15°	1.116
20°	1.161
25°	1.210
30°	1.261
35°	1.321
40°	1.384
45°	1.454
50°	1.532
60°	1.715
65°	1.823
70°	1.946

$$\text{Sp. Gr.} = \frac{144.3}{144.3 - n}.$$

FOR LIQUIDS LIGHTER THAN WATER.

Baumé.	*Specific Gravity.*
10°	1.000
15°	0.966
20°	0.935
25°	0.905
30°	0.878
35°	0.852
40°	0.827
45°	0.804
50°	0.783
55°	0.762
60°	0.742

$$\text{Sp. Gr.} = \frac{144.3}{134.3 + n}.$$

n = degree of Baumé.

Such scales are unsatisfactory, as their equivalents vary in different instruments and different countries.

the point to which it sinks on the stem, and referring to a series of tables belonging to the instrument, the specific gravity is obtained.

Fig. 57.

Urinometer with Cylinder. (Squibb.)

Saccharometers are intended to show the specific gravity of sugar solutions; the scale is so arranged as to indicate directly the percentage of sugar.

The *Elæometer* is an instrument for ascertaining the specific gravity of fixed oils.

The *Lactometer* is employed to ascertain the specific gravity of milk, the scale indicating the percentage of added water.

The *Urinometer* is a small areometer with its scale limited to the specific gravity of urine, usually from 1.000 to 1.060. Most of these instruments are usually very faulty and inaccurate and should never be relied upon unless obtained from a reliable source, or verified. A form offered by Dr. Squibb (Fig. 57), is furnished with a special cylinder having its sides indented so as prevent the instrument from remaining in contact with the sides of the cylinder. Should this happen, the friction and cohesion with the sharp edge of one of these indentations will be reduced to a minimum. In using an areometer it must be observed that the instrument should float freely, and should not adhere to the sides of the jar, otherwise the *cohesion* between the instrument and sides of the jar would prevent a free movement up and down in the liquid, and thus give rise to false readings. The bulb of an areometer is best shaped after that of a double cone, as in Fig. 57, so that there is but a single point which may come in contact with the side of the jar, thus reducing the friction and cohesion to a minimum.

(*c*) DETERMINATION OF SPECIFIC GRAVITY BY MEANS OF THE SPECIFIC GRAVITY BALANCE.—*Westphal Specific Gravity Balance.*—The application of this depends upon the principle that any selected body, when immersed in different liquids, loses exactly the *weight* of its own volume of that liquid. If the same body be immersed in different liquids, it will be seen that its loss in weight will be in proportion to their specific gravities. The small thermometer

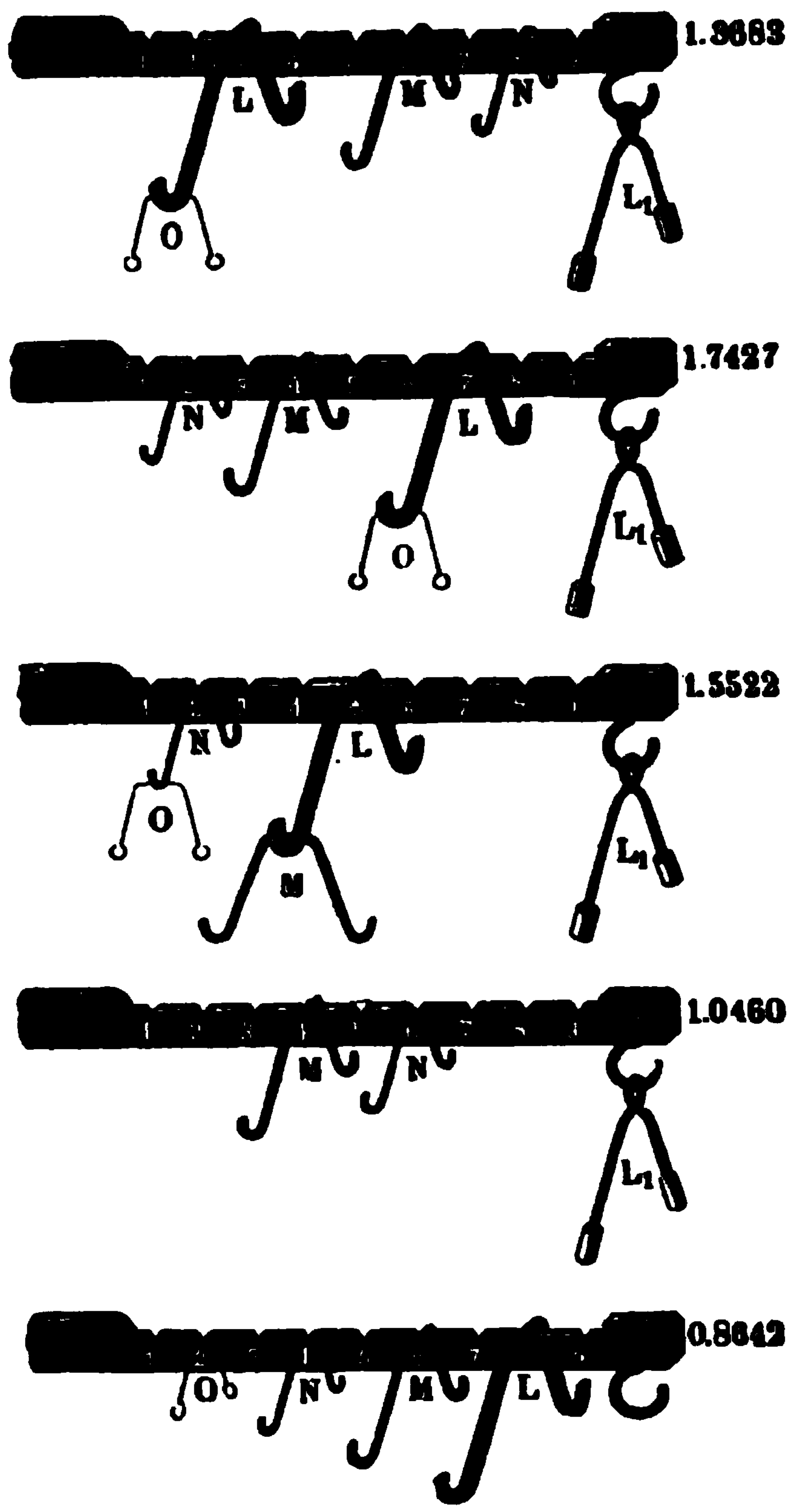
FIG. 58.

Westphal Specific Gravity Balance.

suspended from the arm at K is held in equilibrium by a counter-balancing weight at J. When placed in a liquid, the arm HK rises; riders are then placed upon the beam, in the notches indicated, until equilibrium is restored. The riders L or L_1 are equal in weight to the loss sustained by the thermometer in distilled water (4° C.), the rider M = $\frac{1}{10}$, the rider N = $\frac{1}{100}$, and O = $\frac{1}{1000}$ of the weight of L or L_1. When L or L_1 is placed on the hook at K it indicates the specific gravity of 1.000; when the

other L is placed at 3 it denotes 0.3. Hence, when one of these riders (L or L_1) is placed at K, and the other at 3, and equilibrium is thus restored, the liquid has the specific gravity 1.300. The rider M the second, and N the third, and O furnishes the fourth decimal place. Fig. 59 illustrates the use of the apparatus sufficiently.

FIG. 59.



Beam of Westphal Balance, showing Position of Weights.

Fig. 60 illustrates a simpler form, known as *Mohr's Specific Gravity Balance;* it will be seen from this, that any balance can be used for this purpose by detaching a pan and suspending a short thermometer in its stead by means of a fine platinum wire, then counterpoising both arms by adding weights to the side requiring it. The further operation is the same as that with the Westphal balance.

Jolly's Spiral Balance.—This consists of a spiral vertical spring suspended from an upright beam; on the side of this

beam facing the spiral, is a long mirror which is graduated

FIG. 60.

Mohr's Specific Gravity Balance.

FIG. 61.

into millimeters. The spiral supports two scale pans, one some distance above the other. Just above the upper pan (at B) is a glass bead which serves as an indicator. To take the specific gravity of a solid, the lower pan (D) is immersed in water, the solid placed in the upper pan (C), and the division on the index on the mirror opposite the bead is noted. The solid is removed and weights added until the bead is opposite the same scale division as before. This constitutes the weight of the solid. The solid is then placed in the lower pan and the weights adjusted until the bead again comes to the same number; this constitutes the weight of the volume of water displaced by the solid; then apply rule 1 (page 35).

(*d*) SPRENGEL SPECIFIC GRAVITY TUBE.—This instrument is well adapted for small quantities of fluids and is extremely accurate. It consists of a U-shaped tube terminating in two capillary tubes bent in opposite directions. The liquid to be examined is aspirated into the tube until the latter is filled; the tube is then placed in a beaker of water having the desired temperature, the two arms resting on the edge of the beaker. When the

temperature of the contained liquid is constant (shown by the cessation of movement of the liquid in the capillary tube), the excess of fluid is removed by means of filter paper from the tip *a* until the liquid in the other capillary reaches the mark *m*; the tube and contents are then weighed, and the capacity of the tube in distilled water being known, the specific gravity is obtained as usual.

FIG. 62.

Sprengel Specific Gravity Tube.

(*e*) DETERMINATION OF SPECIFIC GRAVITY BY WEIGHING GIVEN VOLUMES OF SOLUTIONS.—A cylinder or graduate is counterbalanced, and the liquid to be examined is poured in to any definite measure and weighed. This weight is then divided by the weight of a like volume of water at the same temperature. Thus, if we were to *weigh* a fluidounce of a liquid, we would then divide that weight by 455.7 (the weight of one fluidounce of distilled water at 15.5° C.). Should we have measured off 10 cubic centimeters of the fluid, we then divide its weight in grammes by 10 (the weight of 10 Cc. of distilled water).

(*f*) LOVI'S SPECIFIC GRAVITY BEADS.—These are small hollow globes of glass, having specific gravity figures etched on their

FIG. 63.

Specific Gravity of Solid Fats, by means of the Westphal Balance.

FIG. 64.

Specific Gravity of Solid Fats, by means of Areometer.

surfaces. When thrown into a fluid they will rise and float to the surface if lighter than the fluid, or sink to the bottom if heavier; but when any of them remain indifferently suspended at any level, then the liquid has the specific gravity engraved on the beads, if these are correct. These are of special use in the evaporation of liquids to attain certain densities. They will show a difference in specific gravity of 0.001. They are sometimes used in the distillation of ether, the operation being carried on until one of them of specific gravity 0.735 begins to float.

DETERMINATION OF THE SPECIFIC GRAVITY OF FATS AND OILS (solid at normal temperature).—Fig. 63 illustrates the apparatus of Benedikt, in which the fat is placed in the tube D, the temperature of which is regulated by the paraffin bath C, which in turn is heated by the water bath B. The specific gravity is ascertained as usual with the Westphal's balance, the temperature being taken into consideration. Fig. 64 illustrates another form, in which an areometer is floated in the melted fat.

SPECIFIC VOLUME.*

As applied in pharmacy, specific volume is the volume of a certain liquid compared with the volume of an equal weight of another, which is selected as standard. The standard for comparison is distilled water, usually at 15.5° C. (60° F.). As specific gravity is obtained by the comparison of the *weight* of a given *volume* of a liquid or solid with an equal volume of water (as unity), so is specific volume obtained by the comparison of the *volume* of a given *weight* of a liquid body with an equal weight of water. Specific volume, therefore, is simply the reverse of specific gravity.

Specific volume is the quotient obtained by dividing unity by the specific gravity; that is, $\frac{1,000}{\text{Specific Gravity}}$ = Specific Volume. We find that a pound of glycerin measures less, while a pound of ether measures more, than a pound of water; a kilogramme of mercury will occupy less bulk, while the same weight of benzin will occupy more than a kilogramme (1000 Cc.) of water. The knowledge of the specific volume of a fluid will then enable us to ascertain the bulk occupied by a given weight of it. Since the capacity of all graduated or gauged vessels is based on the volume of water they will hold, the specific volume factor will express at a glance the weight capacity of the container. Water at 15.5° C. being unity (1.000), we thus find the specific volume of glycerin to be $\frac{1.000}{1.25 \text{ sp. gr.}} = 0.8$; that of ether, $\frac{1.000}{0.725 \text{ sp. gr.}} = 1.38$; that of chloroform, $\frac{1.000}{1.483 \text{ sp. gr.}} = 0.674$. Therefore, one fluid pint of water, about $\frac{4}{5}$ of a pint of glycerin, about $1\frac{2}{5}$ of a pint of ether,

* This term should not be confounded with the term "specific volume" as applied to chemical physics, which is also defined as "atomic volume," or "molecular volume."

and about ⅗ of a pint of chloroform will all be of the same weight. The *actual* volume occupied by a given weight of a liquid is found by the following rule:—

Multiply the volume of an equal weight of water by the specific volume of the liquid.

Example.—How many cubic centimeters will one kilogramme of chloroform measure? A kilogramme of water measures 1000 Cc.; then, $1000 \times 0.674 = 674$ cubic centimeters of chloroform.

Example.—How many fluidounces will 100 av. ounces of glycerin measure? 100 av. ounces of water measure 96.01 fluidounces; then, 96.01×0.80 (sp. vol. of glycerin) $= 76.8 +$ fluidounces of glycerin.

PRACTICAL EXERCISES IN SPECIFIC GRAVITY AND SPECIFIC VOLUME.

Example.—If 10 cubic centimeters of a liquid weigh 15 grammes, what is its specific gravity? 10 Cc. of distilled water weigh 10 Gm., hence $\frac{15}{10} = 1.50$ is the specific gravity.

Example.—If one fluidounce of a liquid weighs 569.63 grains, what is its specific gravity? One fluidounce of distilled water weighs 455.7 grains, hence $\frac{569.63}{455.7} = 1.25$ is the specific gravity.

Example.—What is the weight of a pint of glycerin? We know that a pint of distilled water weighs 7291.11 grains, and the specific gravity of glycerin is 1.25; hence we multiply 7291.11 by 1.25, which gives us $9113.8 +$ grains.

Example.—Liquor Ferri Chloridi (sp. gr. 1.387) contains 37.8 per cent. of anhydrous salt; how much of this salt is in each 100 cubic centimeters of the solution? The weight of 100 Cc. of water is 100 Gm., this multiplied by 1.387 gives the weight of 100 Cc. of the solution, which is 138.7 Gm.; now, 37.8 per cent. of this weight would be $52.42 +$ Gm.

Example.—What will be the capacity of a flask which will hold 7 av. pounds of glycerin U. S. P.? Seven avoirdupois pounds of distilled water weigh 49,000 grains; this, divided by 455.7 gives $107.52 +$ fluidounces, the bulk occupied by 7 avoirdupois pounds of water; since the specific volume of glycerin is 0.80, we have $107.36 \times 0.80 = 86.01 +$ fluidounces ($5.37 +$ pints), which will be the capacity necessary to hold this weight of glycerin.

Example.—An apothecary returned to his dealer 5 pints of oleic acid (sp. gr. 0.900), valued at 40 cents per pound (av.), and received in return 117 cubic centimeters of mercury (sp. gr. 13.5), valued at 54 cents a pound (av.): did the dealer gain or lose by the transaction?

5 pints of water weigh 5.205 av. pounds; then, if the specific gravity of the oleic acid be 0 900, the weight of 5 pints of it would be $5.205 \times 0.900 = 4.684$ av. pounds. Its value would then be $\$0.40 \times 4.684 = \$1.87 +$.

117 Cc. of water weighs 117 Gm., and if the specific gravity of mercury is 13.5, it would weigh $117 \times 13.5 = 1579.5$ Gm or $3.48 +$ av. pounds. The value will be $\$0.54 \times 3.48 = \$1.87 +$. Hence, there will be neither loss nor gain.

Example.—A piece of metal weighs 100 grammes; its specific gravity is 7.6. When immersed in syrup it loses 16.9 grammes weight. What is the specific gravity of the syrup? We use the following proportion: as the weight of the body in air is to its specific gravity, so is its loss of weight immersed in the liquid, to the specific gravity of that liquid.

That is, as 100 : 7.6 :: 16.9 : x.

x = 1.28, sp. gr. of the syrup.

***Example.*—A piece of mineral weighs 1 av. ounce; when placed in a graduate containing 1 fluidounce of water, the volume of water was increased to 9 fluidrachms. What is the specific gravity of the mineral?**

The volume of water displaced is 1 fluidrachm, which weighs 56.96 grains, then apply rule (page 35), $\frac{437.5}{56.96} = 7.68$ the specific gravity of the mineral.

For further examples the student is referred to Oldberg's "Pharmaceutical Problems and Exercises."

TABLE OF SPECIFIC GRAVITIES, U. S. P.

Temperature, 15° C., 59° F., unless otherwise specified.

Acidum Aceticum,	1.048
Acidum Aceticum Dilutum,	1.008
Acidum Aceticum Glaciale,	1.058
Acidum Hydrobromicum Dilutum,	1.077
Acidum Hydrochloricum,	1.163
Acidum Hydrochloricum Dilutum,	1.050
Acidum Hypophosphorosum Dilutum,	1.046
Acidum Lacticum, about	1.213
Acidum Nitricum, about	1.414
Acidum Nitricum Dilutum, about	1.057
Acidum Oleicum, about	0.900
Acidum Phosphoricum, not below	1.710
Acidum Phosphoricum Dilutum, about	1.057
Acidum Sulphuricum, not below	1.835
Acidum Sulphuricum Aromaticum, about	0.939
Acidum Sulphuricum Dilutum, about	1.070
Acidum Sulphurosum, not less than	1.035
Adeps,	0.932
Æther,	0.725 to .728
Æther Aceticus,	0.893 to 0.895
Alcohol, about,	0.820
Alcohol Absolutum, not higher than	0.797
Alcohol Deodoratum, about	0.816
Alcohol Dilutum, at 15° C., about	0.936
Alcohol Dilutum, at 15.6° C., about	0.937
Alcohol Dilutum, at 25° C., about	0.930
Amyl Nitris,	0.870 to 0.880
Aqua Ammoniæ,	0.960
Aqua Ammoniæ Fortior,	0.901
Aqua Hydrogenii Dioxidi, about	1.006 to 1.012
Balsamum Peruvianum,	1.135 to 1.150
Benzinum,	0.670 to 0.675
Bromum,	2.990
Camphora,	0.995
Carbonei Disulphidum,	1.268 to 1.269
Cera Alba,	0.965 to 0.075
Cera Flava,	0.955 to 0.967
Cetaceum, about	0.945
Chloroformum, at 15° C., not below	1.490
Chloroformum, at 25° C., not below	1.473
Copaiba,	0.940 to 0.990
Creosotum, not below	1.070
Eucalyptol,	0.930
Fel Bovis,	1.018 to 1.028
Glycerinum, not less than	1.250
Hydrargyrum,	13.5584
Iodoformum,	2.000
Iodum, at 17° C.,	4.948
Liquor Ferri Acetatis, about	1.160
Liquor Ferri Chloridi, about	1.387
Liquor Ferri Citratis, about	1.250
Liquor Ferri Nitratis, about	1.050
Liquor Ferri Subsulphatis, about	1.550
Liquor Ferri Tersulphatis, about	1.320
Liquor Hydrargyri Nitratis, about	2.100
Liquor Plumbi Subacetatis, about	1.195
Liquor Potassæ, about	1.036
Liquor Sodæ, about	1.059
Liquor Sodæ Chloratæ, about	1.052
Liquor Sodii Silicatis,	1.300 to 1.400
Liquor Zinci Chloridi, about	1.535
Mel,	1.375
Methyl Salicylas,	1.183 to 1.185
Oleum Adipis,	0.910 to 0.920
Oleum Æthereum,	0.910
Oleum Amygdalæ Amaræ,	1.060 to 1.070
Oleum Amygdalæ Expressum,	0.915 to 0.920
Oleum Anisi, about (17° C.),	0.980 to 0.990
Oleum Aurantii Corticis, about	0.850
Oleum Aurantii Florum,	0.875 to 0.890
Oleum Bergamottæ,	0.880 to 0.885
Oleum Cadinum, about	0.990
Oleum Cajuputi,	0.922 to 0.929
Oleum Cari,	0.910 to 0.920
Oleum Caryophylli,	1.060 to 1.067
Oleum Chenopodii, about	0.970
Oleum Cinnamomi,	1.055 to 1.065
Oleum Copaibæ,	0.890 to 0.910
Oleum Coriandri,	0.870 to 0.885
Oleum Cubebæ, about	0.920
Oleum Erigerontis, about	0.850
Oleum Eucalypti,	0.915 to 0.925
Oleum Fœniculi, not less than,	0.960
Oleum Gaultheriæ,	1.175 to 1.185
Oleum Gossypii Seminis,	0.920 to 0.930
Oleum Hedeomæ,	0.930 to 0.940
Oleum Juniperi,	0.850 to 0.890
Oleum Lavandulæ Florum,	0.885 to 0.897
Oleum Limonis,	0.858 to 0.859
Oleum Lini,	0.930 to 0.940
Oleum Menthæ Piperitæ,	0.900 to 0.920
Oleum Menthæ Viridis,	0.930 to 0.940
Oleum Morrhuæ,	0.920 to 0.925
Oleum Myrciæ,	0.975 to 0.990
Oleum Myristicæ,	0.870 to 0.900
Oleum Olivæ,	0.915 to 0.918
Oleum Picis Liquidæ, about	0.970
Oleum Pimentæ,	1.045 to 1.055
Oleum Ricini,	0.950 to 0.970
Oleum Rosæ,	0.886 to 0.880
Oleum Rosmarini,	0.895 to 0.915
Oleum Sabinæ,	0.910 to 0.940
Oleum Santali,	0.970 to 0.978
Oleum Sassafras,	1.070 to 1.090
Oleum Sesami,	0.919 to 0.923
Oleum Sinapis Volatile,	1.018 to 1.029
Oleum Terebinthinæ,	0.855 to 0.870
Oleum Terebinthinæ Rectificatum,	0.855 to 0.865
Oleum Theobromatis,	0.970 to 0.980
Oleum Thymi,	0.900 to 0.930
Oleum Tiglii,	0.940 to 0.960
Petrolatum Liquidum,	0.875 to 0.945
Petrolatum Molle at 60° C., (140° F.),	0.820 to 0.840
Petrolatum Spissum, at 60° C. (140° F.),	0.820 to 8.50
Phosphorus, at 10° C. (50° F.),	1.830
Resina,	1.070 to 1.080
Spiritus Ætheris Nitrosi, about	.820
Spiritus Ammoniæ, about	0.810
Spiritus Ammoniæ Aromaticus,	0.905
Spiritus Frumenti,	0.917 to 0.930
Spiritus Glonoini,	0.826 to 0.832
Spiritus Vini Gallici,	0.925 to 0.941
Syrupus, about,	1.317
Syrupus Acidi Hydriodici, about	1.313
Terebenum, about	0.862
Thymol (as solid),	1.069
Tinctura Ferri Chloridi, about	0.960
Vinum Album, at 15 6° C., not less than	0.990
Vinum Album, not more than	1.010
Vinum Rubrum, at 15.6° C., not less than	0.989
Vinum Rubrum, not more than	1.010
Zincum, cast 6.900, rolled,	7.200

CHAPTER III.

HEAT.

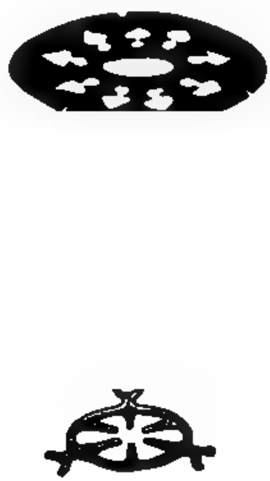
ITS VARIOUS APPLICATIONS IN PHARMACY.

Combustion is chemical combination attended with evolution of light and heat. A flame is a stream of gas or vapor raised to the temperature of ignition. Its illuminating and heating power varies with the nature of the products formed; the presence of a solid body in the flame increases the illuminating power. The flame of hydrogen or alcohol is pale, or almost colorless, because

Fig. 65.

Alcohol Lamp.

Fig. 66.



Berzelius' Alcohol Lamp for High Temperatures.

it only contains gaseous products of combustion. The flames of candles, lamps, and coal gas possess high illuminating power, because the high temperature produced decomposes certain of the gases with the production of carbon, which not being entirely consumed, becomes incandescent in the flame. Coal gas, when burnt so that it may become mixed with an adequate supply of air, as in the Bunsen burner, gives a flame which is almost devoid of luminosity. For technical purposes the valuation of different fuels is important. The comparative value of fuel is ascertained by estimating the number of heat units (calorics) disengaged during combustion. By caloric is meant the number of heat units necessary to raise one gramme of water from 0° to 1° C.

It may also be expressed by the quantity of water warmed one degree by one kilogramme of the material; for example:—

1 kilo of hard wood	heats	3600	kilos of water from 0° to 1° C.
1 " " bituminous coal	"	6000	" " " " " " "

Then the value of wood as a heat-producer, compared with coal, is as 3600 is to 6000, or 3 to 5; that is, 3 parts of coal will give as much heat as 5 parts of wood. Compared as to their heating or evaporating power

1 kilo of Hydrogen	is capable of evaporating	53	kilos of water.
1 " " Illuminating Gas	" " " "	18	" " "
1 " " Coal Oil	" " " "	11.8	" " "
1 " " Alcohol	" " " "	11.2	" " "
1 " " Coal	" " " "	9.0	" " "
1 " " Wood	" " " "	5.5	" " "

For detailed explanations of the value and uses of different fuels, with the arrangement of furnaces, ranges, etc., the reader must be referred to the text-books on Technical Chemistry. The modern apothecary employs, as a source of heat, either alcohol, benzin, coal oil, illuminating gas, or steam. Owing to the high price of alcohol, this liquid is at present used for heating purposes, only where coal-gas is not accessible, or for some reason objectionable. For purposes where a lower degree of heat is needed, the simple form of the alcohol lamp (Fig. 65) is employed; should it be desirable to have a more luminous flame, a small amount of oil of turpentine may be added. For a higher degree of heat we have heretofore employed the Berzelius lamp (Fig. 66). This has, however, been greatly improved upon in the newer Bunsen lamp of Barthel (Fig. 67). This is a very practical and safe lamp, capable of producing a very high degree of heat, equal to that of the Bunsen gas burner. The burner consists of a thick metal tube supported on a foot and separated in the center into two parts (C, D). In the upper portion the flame is generated, and the heat therefrom vaporizes the alcohol in the lower portion. A uniform vapor is obtained by the interposition of a wire gauze (M), and the size of the flame is regulated by the screw (S, R) which governs the flow of vapor. The tube H conveys the alco-

FIG. 67.

Barthel Spirit Lamp.

hol to the flame and contains a sieve to filter the alcohol. The container is connected with the burner by a metallic tube.

To heat one liter of water from a temperature of 15° C. to 100° C. (59° F. to 212° F.), Barthel's alcohol Bunsen burner, after model B, requires seven and three-fourths minutes, with a consumption of 25 Gm. alcohol. This lamp may be used for benzin as well as alcohol. The market affords all forms of coal-oil stoves which are cheap and convenient, but they must be kept scrupulously clean, and the wicks well trimmed to avoid a smoky flame. The cheapness of illuminating gas has led to its

FIG. 68.

Bunsen Burner.

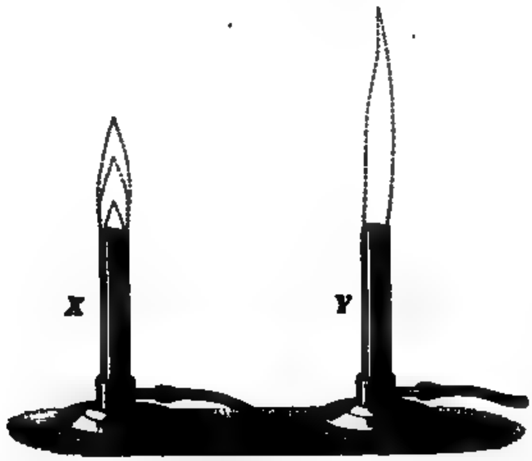
FIG. 69.

Bunsen Burner in Sections.

general adoption for heating purposes. All the various forms of gas stoves depend on the principle of the Bunsen burner, the invention of which revolutionized our methods of heating, and made coal gas the most important of fuels. It was found by Bunsen in 1855, that the admixture of a certain portion of air with coal gas before combustion, caused it to burn with a non-luminous flame of high temperature. Figs. 68 and 69 illustrate the construction of a Bunsen burner. The gas enters at *b*, having its exit at *a*, where it becomes mixed with air which enters at the openings at the base of the burner. The volume of air can be regulated by the movable collar *d;* when this is closed, a lumi-

nous, smoky flame is obtained. The cone *g* placed on *f,f* is intended to prevent the flame from flickering, which is liable to be caused by slight draughts. On viewing a well regulated Bunsen

FIG. 70.



Bunsen Flames. X, Proper Flame. Y, Flame Struck Back.

flame (Fig. 70 x), it will be seen to consist of an inner colorless or pale-blue cone, which is a mixture of cold air and gas, and an

FIG. 72.

FIG. 71.

Bunsen Burner (Seven-tubed).

Erlenmeyer's Burner.

outer mantle, which is the burning mixture of gas and air. If the admission of air below is limited, the outer mantle and tip of the flame become smoky, with a loss in temperature. Should too much air and too little gas be admitted, the flame either be-

comes extinguished or strikes back and burns at the bottom of the lamp where the gas enters; the flame at the orifice then becomes

FIG. 73.

Solid Flame Heating Burner.

FIG. 74.

Fletcher Gas Stove.

FIG. 75.

Gas Stove.

small (Fig. 70 Y), is colored, and devoid of the blue cone; a peculiar, pungent odor (due to acetylene) is at once detected; the lamp becomes very hot, causing the rubber tube to melt, and the escaping gas igniting gives rise to danger of fire. In such cases the gas should be at once turned off, and then readmitted in greater or lesser volume, as may be required. For various operations where a higher degree of heat is required, we have such burners as are illustrated in Figs. 71, 72. For purposes of evaporation, the forms of stoves illustrated in Figs. 73, 74 and 75 are employed. In many chemical operations we employ the "blast lamp" (Figs. 77, 78) which gives an intensely hot flame. The

FIG. 76.

Instantaneous Water Heater.

gas enters at *a* and the air is forced by means of a pair of bellows (foot blower) through *b*. The current of either may be regulated to produce any sized flame at will.

Figs. 77, 78.

Blast Lamp with Cross Section.

MEASURING OF HEAT.

A thermometer is an instrument which is employed to measure temperature. All bodies expand by the action of heat. Gases are the most expansible, in a less degree liquids and solids. Liquids are best suited for the construction of thermometers, for the expansion of solids is too small and that of gases too great. Mercury and absolute alcohol (colored) are the liquids most generally employed, the former being adapted for all temperatures between 350° C. (its boiling point), and –39.4° C (its solidifying point); the latter cannot be used for measuring temperatures above 78.3° C. (its boiling point), it is, however, especially adapted to very low temperatures (solidifying at –130.5° C.). Mercury, because of its great sensibility, non-adhesive qualities, and convex surface, is almost altogether used in making thermometers. These consist of a capillary glass tube, at one extremity of which is blown a small bulb, either cylindrical, spherical or coiled. When it is to be filled, a rubber tube and small funnel is attached at the upper, open end, then very pure mercury is poured into the funnel; on warming, the air is partially driven out, and on cooling, a portion of the mercury is forced down the capillary into the bulb, by the pressure of the atmosphere. This is repeated until the bulb is filled. Then the bulb of the thermometer is heated until the mercury rises and fills the entire tube; at this moment

it is quickly sealed at the extremity. On cooling, the mercury contracts, leaving a vacuum above. The space above the mercury is often filled with nitrogen gas. This is done to avoid any oxidation of the surface of the mercury, which would follow, should any air be present. After filling, the tubes are allowed to stand for some time (six months to two years), to allow for the complete contraction of the glass, after which they are ready for graduation. For this purpose two fixed points are selected which can always be readily reproduced. Experiment has proven to us that ice always melts at the *same* temperature, no

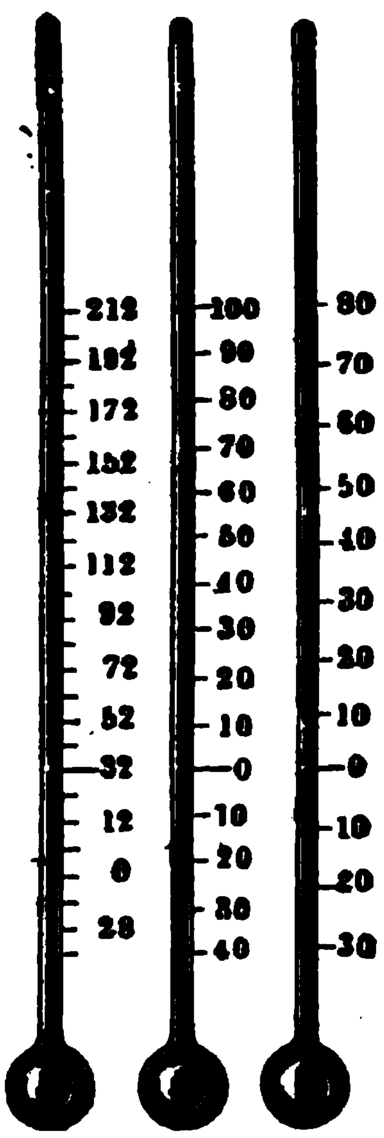
FIG. 79.

Thermometer (Opaque Milk-glass scale).

FIG. 80.

Thermometer (Graduated on Tube).

FIG. 81.



Fahrenheit, Centigrade, Réaumur Thermometers.

matter how great the amount of heat may be. Again, distilled water under the same pressure and in a vessel of the same kind, always boils at the *same* temperature. Hence the first unit selected is the temperature of melting ice, also designated as "freezing point" (viz. of water; and the second unit is the temperature of the steam arising from distilled water boiling in a metal vessel under normal atmospheric pressure (760 Mm). The space between the freezing and boiling points may be divided into any even number of parts. In the case of the Centigrade or Celsius thermometer, it is divided into 100

equal parts, the same scale of graduation being continued above the boiling point (100°) and below the freezing point, which is here marked (0°). The degrees below the zero point are indicated by a minus sign, and those above, by a plus sign before the figure. The latter, however, is omitted in practice. The three most popular thermometric scales are those of Fahrenheit, Réaumur, and Celsius (Centigrade). The Fahrenheit thermometer, which is the household thermometer of England and America, was invented by Fahrenheit, a merchant of Dantzic, in 1709. The temperature of melting ice was marked as 32° and that of boiling distilled water as 212°.* There are 180° between these two points, this being done in view of some old observations on the expansion of mercury. The Réaumur scale, the domestic thermometer of Germany, Austria, and some other European countries, selects the temperature of melting ice as the 0° point, and 80° as the boiling point of water, or more accurately stated as the temperature of the steam arising from boiling distilled water, under the standard pressure of 760 Mm. Between these points it is divided into 80 parts, from the observation, that there are 80 thermal units absorbed, in bringing one kilogramme of ice of the temperature 0°, to water of the temperature 0°. For scientific purposes, the Celsius (Centigrade) scale is the only one employed. The two fixed temperatures are that of melting ice, viz., 0°, and the temperature of steam which issues from distilled water boiling under the standard pressure of 760 millimeters, viz., 100°.

Rules for converting Degrees of the Centigrade Thermometer into those of Fahrenheit, and vice versa. —(Rules for Réaumur are omitted):—

1. Given Celsius (C.) degrees, sought Fahrenheit (F.).

$$\frac{9\ \mathrm{C.}}{5} + 32 = \mathrm{F.}$$

2. Given Fahrenheit (F.) degrees, sought Celsius (C.).

$$\frac{5\ (\mathrm{F.} - 32)}{9} = \mathrm{C.}$$

Examples.—Convert 100° C. into ° F.

$$\frac{9 \times 100}{5} + 32 = \mathrm{F.}\ ;\ \frac{900}{5} + 32 = \mathrm{F.}\ ;\ 180 + 32 = \mathrm{F.}\ ;\ 212 = \mathrm{F.}$$

or,

$$\mathrm{F.} = \frac{9 \times 100}{5} + 32 = (9 \times 20) + 32 = 180 + 32 = 212.$$

Convert 212° F. into ° C.

$$\frac{5\ (212 - 32)}{9} = \mathrm{C.};\ \frac{5 \times 180}{9} = \mathrm{C.};\ 5 \times 20 = \mathrm{C.};\ 100 = \mathrm{C.}$$

or,

$$\mathrm{C} = \frac{5\ (212 - 32)}{9} = \frac{5 \times 180}{9} = 5 \times 20 = 100.$$

* The temperature obtained by mixing equal parts of sal-ammoniac and snow, was selected as the zero point, because the temperature was the lowest then known, and was thought to represent absolute cold.

Of late years a number of improvements have been made in the manufacture of thermometers, particularly in those which are to be employed for estimating extremely high or low temperatures. A Jena laboratory for glass industry has produced a new glass of great resistance, so that a glass thermometer has been made to read to 550° C. (1,022° F.). In this instrument, the capillary above the mercury column is filled with carbonic acid gas. At low temperatures, mercury thermometers have the drawback that, when the temperature sinks to -39.4° C., the mercury freezes. For low temperatures alcohol thermometers are usually employed; but since it is difficult, if not impossible, to obtain the alcohol entirely free from water, their registration cannot be entirely trusted. Anhydrous toluol (colored black) has been proposed as a substitute, its limit being + 170° C. and - 70° C.* Because of its black color, the column is easily distinguished; it expands with great regularity, and being of much less density than mercury, the bulb of the thermometer can be made larger, thus securing greater exactitude in the registration. It, however, does not receive impressions of heat and cold very readily, hence it is very slowly sensitive.†

Conditions of Delicacy.—A delicate thermometer should indicate very small changes of temperature, and should quickly assume the temperature of the surrounding medium. To fulfil this condition, the capillary tube should be very narrow, so that each degree occupies as great a length on the stem as possible, and may easily be subdivided into small fractions. The bulb should be as small as possible, so that it may rapidly assume the temperature of the surrounding medium. Thermometers, even when constructed with the greatest of care, are subject to various sources of error. These are 1st: The bore or calibre of the thermometer may not be uniform. 2d: A gradual contraction of the bulb may cause the zero point to rise. 3d: A gradual expansion of the bulb may cause a lowering of the zero point.

A thermometer bulb after being blown and allowed to cool, continues to contract long after the glass has attained its normal temperature, even for a period of two years or more. Thermometers which have been exposed to prolonged high temperatures suffer a marked expansion of the bulb. For this reason, thermometers which are employed for scientific purposes should be examined from time to time. The most convenient for purposes of comparison and correction, are the so-called "Normal Thermometers." These are very accurate instruments, having been compared with the air thermometer, and are usually accompanied with a table of corrections furnished by some authority engaged in the verifi-

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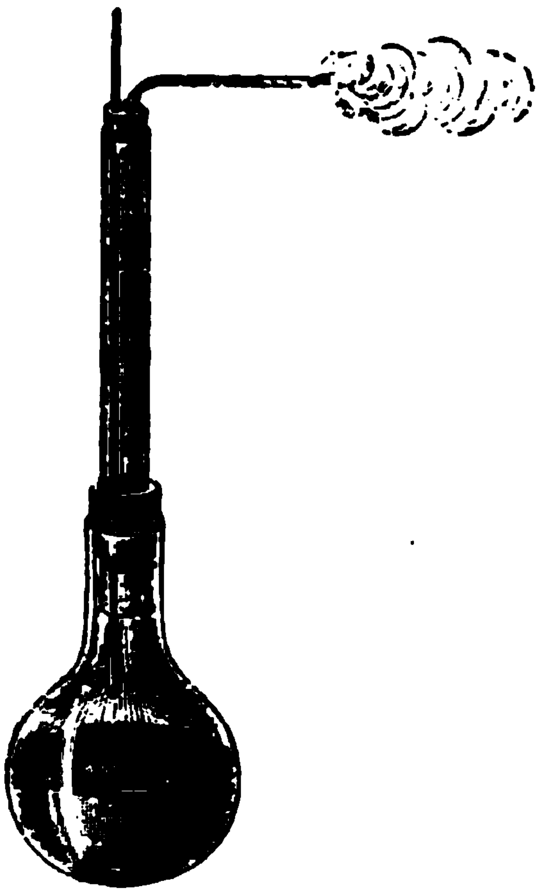
* Must be under pressure, as its boiling point is 111°.

† Messrs. Baly and Chorley have constructed a thermometer of a very resistant glass, which will stand a red heat; employing in place of mercury an alloy of sodium and potassium. The boiling point of this is near 700° C., and congealing point at -8° C. It is graduated from 200° C. on. The capillary above is filled with Nitrogen under a pressure equal to that of the atmosphere outside.

cation of standards. The thermometer to be tested is suspended alongside of a normal instrument, and the bulbs of both immersed in a bath of sulphuric acid, which is slowly heated, under the same conditions as in the determination of melting points (Fig. 88), the temperatures being compared and noted. When such an instrument is not at hand, the best plan is to ascertain the accuracy of the zero and boiling points. To determine the accuracy of the zero point, we fill a funnel with crushed (well washed) ice, so that the water may have free escape; in this the thermometer is immersed so that the top of the mercury column (0° C. or 32° F), is below the surface of the ice. Here it is allowed to remain from 15 to 30 minutes, then the height of the column is noted without removing the instrument, when it should stand at 0° C. or 32° F. For making the readings, a lens should be employed. To ascertain the accuracy of the boiling point, suspend the entire thermometer at least a few degrees above its boiling point mark, in the steam which issues from boiling distilled water, as illustrated in Fig. 82. With the barometer standing at 760 millimeters, the mercury should be stationary at 100° C., or 80° R., or 212° F. If the barometer varies from the standard of 760 Mm., then an increase of pressure of 1 Mm. of mercury produces an elevation of the boiling point by 0.0375° C.; or, an elevation of the boiling point by 1° C. corresponds to a difference of pressure of 26.8 Mm. of mercury. This correction is applied thus: supposing that the boiling point reading was 99.5° and the height of the barometer 752 Mm.; then the required correction would be $\frac{760-752}{26.8} = \frac{8}{26.8} = 0.3°$, therefore, the corrected boiling point would be $99.5° + 0.3° = 99.8°$.

FIG. 82.



Boiling-point Determination.

The results of examination would be entered thus:—

Freezing point, ...	−0.1°.
Boiling "	99.8°.

To calibre the tube, that is to ascertain whether the calibre is uniform throughout, a short portion of the mercury column (an aliquot part of 100°) is detached from the remainder by a slight jerk, and, on inclining the tube it may be made to pass from one portion of the bore to another. If the scale is properly graduated, the column will fill an equal number of divisions throughout.*

* For the accurate calibration of a thermometer see Kohlrausch's "Leitfaden der Praktischen Physik."

BOILING POINT.

Boiling is the conversion of a body from the liquid into the gaseous condition, which takes place from the surface as well as the interior, elastic bubbles of vapor being rapidly produced, which give rise to a bubbling movement throughout the entire liquid. The boiling of a liquid takes place at a constant temperature which depends on the nature of the liquid and the atmospheric pressure. *The Boiling Point is "the temperature at which the evolved vapors overcome the atmospheric pressure,"* or at which the tension of its vapor equals the atmospheric pressure. The temperature of ebullition or the boiling point, rises with increasing, and falls with decreasing pressure. For instance, water boils on the Montblanc under a pressure of about one-half an atmosphere at 86.5° C. Under a pressure of $\frac{1}{160}$ of an atmosphere, it would boil at 0° C. The temperature of the evolved vapors is known as the boiling point, and this is entirely independent of the various conditions which influence the boiling of liquids, since the temperature of the boiling liquid depends on the amount of air bubbles, the nature of the containing vessel, its surface, the nature and cohesion of the fluid, the atmospheric pressure, etc. Since the boiling point is an unchangeable physical constant, the determination of this affords, like that of the "melting point," a means of identification, and gives us a very important criterion concerning the purity, of many substances. For determining the boiling point of liquids, an apparatus arranged as shown in Fig. 82 may be employed; but should the liquid be inflammable, the apparatus must be so arranged that the vapors may be removed and condensed, asshownin Fig. 84. Forthis purpose a "fractionating flask" (Fig. 83) is selected. The thermometer should extend far enough down the neck to have its bulb slightly below the side exit, and it should never come in contact with the boiling liquid itself. The flask, which should never be filled more than about ⅔ full, as shown in the

FIG. 83.

Fractionating Flask (Measurements in Centimeters).

illustration, is then connected with a condenser and distillation commenced, by heating the flask very slowly over a low flame. As soon as the liquid begins to boil, the thermometer ceases rising and remains stationery. Care must be taken not to heat too rapidly, beginning with a small flame and slowly increasing if necessary.

FIG. 84.

Apparatus for Fractional Distillation.

MELTING POINT.

By determining the melting point we are able to judge, not only as to the identity, but also as to the purity of many organic solids. The presence of but minute amounts of admixtures mostly influences the melting point by either raising or lowering it. The constancy of the melting point of a substance after recrystallization, is a proof of its purity. To determine the melting point, we first prepare one or more suitable tubes. This is done by heating uniformly a tube of light fusible glass in a strong gas flame, drawing it out when sufficiently soft, as illustrated in Figure 85, then cutting it in the middle of the capillary and at both of the enlarged extremities, and closing the tips of the pointed extremities in the flame. The substance to be examined is then reduced to a fine powder, placed on a watch glass and either dried in an oven at 100° C., or allowed to stand over sulphuric acid in a desiccator, until it ceases to lose weight. The fine powder is introduced into the tube and by careful tapping is brought to the bottom. The capillary is filled to a height equal

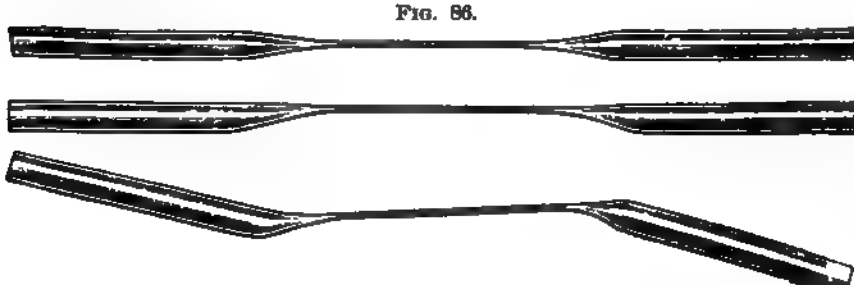
to that of the mercury in the bulb of the thermometer. Care should be taken that the powder is not packed too firmly in the tube. Then the one or two tubes are fastened to the thermometer by means of a rubber band (Fig. 87), care being taken that it is at least 4 Cm. (1½ inches) above the surface of the liquid into which the tubes are inserted. The thermometer with attached tube, is secured in a clamp and lowered into a beaker glass (100–120 Cc.), which is filled about two-thirds full

FIG. 85.

Drawing Out Tubing.

with any clear liquid which is a good conductor of heat. The extremity of the thermometer should extend to within about 1.2 Cm. (or ½ inch) of the bottom. The beaker is then placed on a wire gauze and heated slowly by a low flame, the liquid being carefully stirred so as to insure a uniform equalization of the temperature throughout. Most substances shrink just before melting, which usually takes place suddenly. The moment when this occurs, note the temperature of the thermometer. It

FIG. 86.



Cutting Capillary Tubes for Melting Point Determination.

should be observed whether the body melts suddenly and entirely, or whether a portion melts and the balance requires a higher temperature and greater length of time until a clear fluid results, this extending over several degrees of temperature. When such is the case, the substance is not uniform, that is, there may be an admixture of some foreign or allied body of a higher or lower melting point, or it is sometimes due to imperfect drying of the substance. Some bodies melt with decomposition, gener-

ally giving off gases or charring. As fluids for heating, we usually employ

Distilled water for substances which do not melt above	80° C.
Pure concentrated sulphuric acid for substances which do not melt above	180° C.
Paraffin for substances which do not melt above	300° C.

Sulphuric acid is most generally employed for this purpose.

FIG. 87.

Melting Point Tubes in Position.

FIG. 88.

Taking Melting Point in Bath of Sulphuric Acid.

Another form of apparatus (Fig. 90) is often employed, which is essentially a double-mantled tube. The outer tube (*b*, *b*) is filled with sulphuric acid, introduced at *d*, the inner one (*c*) serves as an air-bath, in which the entire thermometer is suspended, being thus subjected to a uniform temperature.

MELTING AND CONGEALING POINT OF FATS AND WAXES.

There are various methods in use for determining the melting point of fats, which yield more or less discordant results. Some methods rely upon the temperature at which the fat *begins* to melt, others upon the temperature at which the mass is *entirely*

melted and clear; still others, upon the temperature when the fat begins to soften. The simplest method is to draw, by suction, a little of the melted fat into a capillary tube, to fuse the end of this in a flame; when cool, to fasten it to a thermometer and to proceed as already directed. Bensemann suggests that a few drops of melted fat be brought to the position *a* (Fig. 91), by holding the tube horizontally and tipping, then cooling by drop-

Fig. 89.

Long-neck Flask for Melting Point Determinations.

Fig. 90.

Air-Bath for Melting Point Determinations.

Fig. 91.

Tubes for Fusing Point Determinations.

ping water or ether on the outside; placing in a beaker of cold water, attaching to a thermometer, and then warming very slowly. The moment when the solid particle of fat becomes loosened and begins to flow down the side, the temperature is taken as the "Beginning Point;" the moment it unites at *b* to form a clear globule of melted fat, the temperature is taken as "Complete Melting Point."

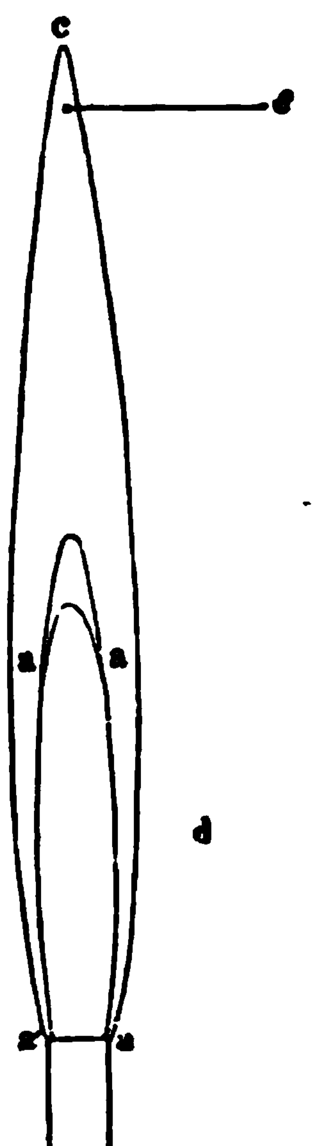
CHAPTER IV.

APPLICATIONS OF HEAT IN VARIOUS OPERATIONS.

Under this head, those operations which require a high degree of temperature will be considered first.

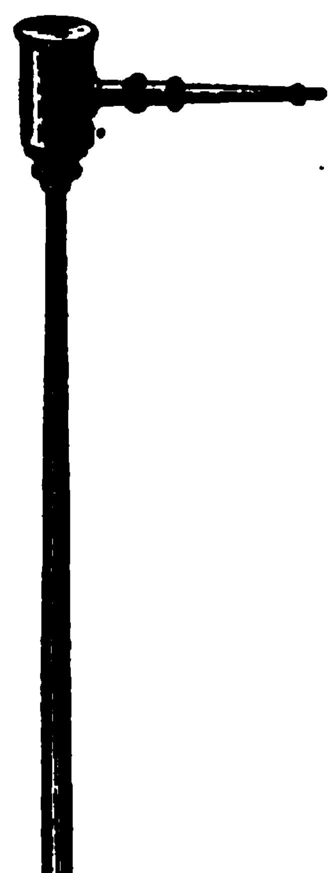
USE OF THE BLOWPIPE.—A knowledge of the uses of the blowpipe is important, because of its various applications in analytical chemistry. For a thorough treatise upon this subject, the student is referred to Plattner's "Blowpipe Analysis." In using the blowpipe (Fig. 93), a constant and uniform blast of air must be kept

FIG. 92.



Sectional View of Bunsen Flame.

FIG. 93.



Blowpipe.

up through the tube by the operator, who must use the muscles of his cheeks as bellows, keeping them constantly distended, supplying air as needed. This blast of air passing through the dark cone of any illuminated flame, produces the same effect as that of the Bunsen flame, only that the flame becomes long and pointed and of a very high temperature, being concentrated on a very small amount of space. The flame (Fig. 92) is divided into

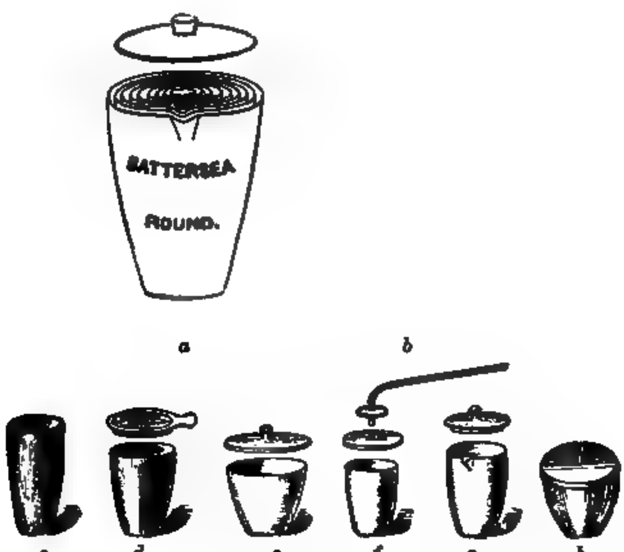
two parts, the inner or deoxidizing zone at *a a* (or *a*, Fig. 94), for here, where some of the gas is yet unoxidized or unconsumed, oxygen is removed from metallic oxides. The outer zone at *e* (or *b*, Fig. 94) is called the oxidizing flame, for by the high temperature and free access of oxygen, metals are easily oxidized. When a flame of very high temperature is desired, the Blast-lamp (Figs. 77–78) is best employed.

FIG. 94.

Blowpipe Flame.

OPERATIONS WITH THE CRUCIBLE.—Crucibles are cup-shaped vessels of round or triangular shape, made of such material that they will stand extremely high temperatures. They are employed in carrying on the process of ignition or smelting. For large operations the Hessian or graphite crucible is employed. The former is somewhat porous, hence only adapted for crude work, the latter withstands a very high degree of heat and rapid changes of temperature without fracture. For general operations of the chemist or apothecary, the porcelain, platinum, silver, or

FIG. 95.



Crucibles. *a*, *b*. Hessian. *c*. Graphite. *d*. Platinum. *e*, *f*. Porcelain. *g*. Clay. *h*. Copper.

nickel crucible is employed. Porcelain crucibles are best adapted for general use, because of their cheapness, and also because less care is necessary to keep them in order. Moist substances should never be heated in such a crucible over the naked flame; the

substance should be first dried by placing the crucible and moist contents on a water bath or in a drying oven, and when thoroughly dry, placing the substance in the crucible and the latter on a pipe-stem triangle and carefully heating, increasing gradually to redness. These crucibles should not be employed for fusing caustic alkalies. Platinum crucibles are best adapted for all kinds of work; wet precipitates may be thrown in and ignited at once. They will stand an intense degree of heat, and may be also rapidly heated and cooled. Mixtures that give off free chlorine or contain lead compounds should not be heated in them.* They should be cleansed from time to time by scouring with moist rotten stone; sand should not be used. Silver or nickel crucibles are best adapted for fusing caustic alkalies. Care should be observed not to heat too strongly, for there is danger of melting the silver.

The following operations require a high degree of heat.

IGNITION.—Ignition is employed in analysis to remove the last portions of moisture, or of organic or volatile constituents, from inorganic substances, in order to convert the latter into stable weighable compounds. The filter containing the precipitate is folded, laid in the crucible, which is then placed on the triangle and heated slowly, until the filter is reduced to ash; then the heat is increased to dull redness, in which case the blast lamp is necessary; when sufficiently cool it is placed in the desiccator, being handled with a pair of crucible tongs. In the early stage of the operation the crucible lid is removed, until all carbonaceous matter is burned off; then the cover is replaced and strong heat applied.

FIG. 96.

Ignition with Blast Lamp.

Examples:—A solution of ferric salt is precipitated by an alkali, and the precipitate washed and dried; ignition then converts the ferric hydrate into ferric oxide, in which condition it is weighed. $Fe_2(OH)_6 = Fe_2O_3 + 3H_2O$. Phosphoric acid is precipitated as magnesium ammonium phosphate ($2MgNH_4PO_4 + 6H_2O$), this on ignition yields $2NH_3$, $7H_2O$ and magnesium pyrophosphate, $Mg_2P_2O_7$. The latter, a stable compound, is weighed.

FUSION.—This is liquefaction of solids by heat. We fuse those solids which liquefy and do not suffer chemical change by heat. In analytical operations, we fuse silver chloride, to preclude the presence of any moisture. Caustic potash and soda are fused to

* Also caustic alkalies, cyanides, or metallic salts mixed with organic matters.

remove all traces of moisture, then moulded into sticks for the sake of convenience. This process is also applied in the preparation of Argenti Nitras Fusus, U. S. P.; likewise with a lower degree of heat in the preparation of cerates, ointments, plasters, etc.

CALCINATION.—Some inorganic substances are strongly heated (until of constant weight), to remove some volatile constituent, as water of hydration or carbonic acid gas. The residue is said to be "calcined."

Example.—Limestone or marble, on being strongly heated, yields calcium oxide (burnt lime). $CaCO_3 = CaO + CO_2$. Magnesium carbonate $(MgCO_3)_4Mg(OH)_2$, when calcined, yields magnesia (MgO), water, and carbonic acid gas.

DEFLAGRATION.—A process wherein we subject an inorganic salt, capable of giving up oxygen, to strong heat with another; decomposition takes place with the formation of a new compound.

For this purpose sodium nitrate or potassium chlorate are usually selected. Thus:—

$NaNO_3$	=	$NaNO_2$	+	O.	$2KClO_3$	=	$2KCl$	+	$3O_2$
Sodium Nitrate.		Sodium Nitrite.		Oxygen.	Potassium Chlorate.		Potassium Chloride.		Oxygen.

TORREFACTION.—The subjection of drugs to roasting, whereby an alteration in their properties and constituents takes place.

Example.—Roasting of coffee, whereby the undesirable constituents are altered, giving rise to the aroma, while the active constituents, caffeine and caffeotannic acid, remain unchanged. Rhubarb possesses cathartic properties, but on roasting, the cathartic principles are destroyed and an astringency is developed.

CARBONIZATION.—The subjection of organic substances to strong heat, out of contact with air.

Example.—Wood charcoal and animal charcoal. When these are burnt in open air, ashes result.

INCINERATION.—This consists in heating organic substances, with access of air until all of the carbonaceous matter has been consumed, yielding an ash. This is employed in such operations where it is desirable to estimate non-combustible (inorganic) matter in organic bodies.

CHAPTER V.

VAPORIZATION.

OPERATIONS REQUIRING A LOWER DEGREE OF HEAT.

The conversion of a liquid into the gaseous condition is designated by the general term—*Vaporization.* As applied in pharmacy, when it is intended to separate a volatile liquid or solvent from a solid, or a more volatile from a less volatile liquid, or for the purpose of concentrating a liquid, the process is called—*Evaporation.* When the volatile portion or portions are sought for, it is called—*Distillation.**

When a volatile is to be separated from a non-volatile solid, it is called—*Sublimation.*

When solids are deprived of moisture at a low temperature, it is called—*Desiccation.*

When crystalline salts are deprived of their water of crystallization by means of heat, it is called—*Exsiccation.*

The subjects of Evaporation, Distillation, Sublimation, Desiccation, and Exsiccation are explained in the chapters following: while the subject of Granulation follows the chapter on Crystallization.

EVAPORATION.

In pharmaceutical operations, we resort to evaporation for the concentration of liquids, the collection of a dissolved body (extracts), or for the purposes of crystallization. For pharmaceutical or technico-chemical purposes, the principal object to be considered, is the saving of time and fuel. In quantitative analysis this is not considered, care and attention being directed to guard against loss or contamination of the substance operated upon.

According to the nature of the solvent and dissolved body, the method of evaporation may vary, as to the vessel in which it is carried on, or the nature of the source of heat. The rapidity of evaporation depends upon:

1st. The amount of surface of the liquid exposed.
2d. The temperature of the liquid.
3d. The nature of the liquid and dissolved body.
4th. The atmospheric pressure, also the atmospheric humidity.
5th. The nature of the vessel.

1st. The larger the amount of surface exposed to the atmosphere, the more rapid is the rate of evaporation, for it is evident, that a liquid, contained in a shallow evaporating dish, will evaporate more rapidly if exposed to the same temperature, than the same quantity contained in a deep narrow vessel. Shallow vessels favor ebullition, since there is a lesser weight of liquid above the source of heat, thereby affording less resistance to the

* In some instances, distillation is employed as an economical method of evaporation, the product remaining in the still being that portion sought.

escape of bubbles. When we evaporate below the boiling point, we endeavor to present as much surface as possible to the air;

FIG. 97.

Mechanical Stirring Apparatus for Evaporating Fluids.

hence, by stirring, a fresh surface is constantly brought into contact with the air. This operation may be carried on mechanic-

FIG. 98.

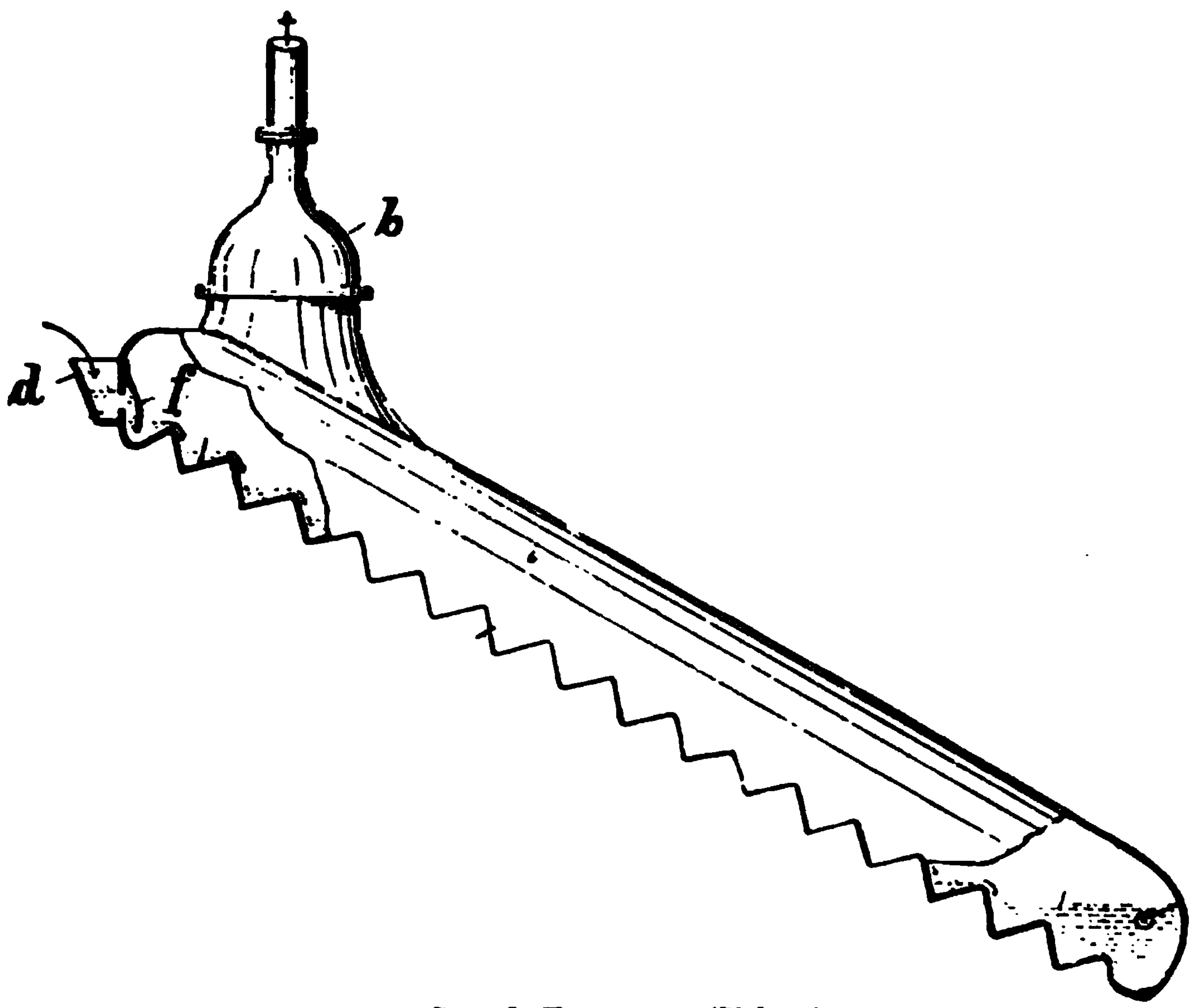
Mechanical Stirring Apparatus.

ally by means of rotating paddles or stirrers as shown in Figs. 97, 98. This method of evaporation is largely employed in pharmaceutical laboratories, when we desire to rapidly concentrate a

fluid at as low a temperature as possible, to avoid injury to the drug. In various industries, where surface evaporation is resorted to, large surfaces are exposed in shallow tanks, over which the flame or hot gases from the furnace are allowed to pass. Fig. 99 illustrates the same principle, but in another form. This patented apparatus of Siebert (Hanau a/M) is employed, particularly in the concentration of sulphuric acid. The acid to be concentrated flows into the pocket at *d*, the blade *f* controls the flow so that only a thin stream trickles down the steps of the heated cascade, the vapors being removed through *b*.

2d. The increase of temperature in a liquid accelerates evap-

FIG. 99.



Cascade Evaporator (Siebert).

oration by increasing the elastic force of the vapors, thereby facilitating their rapid liberation.

3d. The nature of the liquid or solvent, that is, the density and cohesion of liquids, influence the elastic force of the vapors. Relatively light and mobile liquids, as ether or alcohol, evaporate far more rapidly than water, since they allow a rapid escape of the bubbles, while on the contrary, the cohesiveness of a solution, like that of syrup or mucilage, offers considerable resistance.

The presence of a dissolved body raises the boiling point of a liquid materially,* hence, not only is a higher degree of heat required, but the rapidity of evaporation may also be greatly im-

* See Saline Solutions.

peded, by the formation of a crust of saline or other solid matter on the surface of the liquid, which would prevent the escape of steam bubbles.

4th. Influence of atmospheric pressure. As stated, the boiling point of water at normal atmospheric pressure of 760 Mm. (30 in.) is 100° C. (212° F.). If the pressure be decreased, the boiling point also decreases, with an increase of rapidity of evaporation.* If pressure be exerted upon the surface of the liquid, it causes a material rise in the boiling point, diminishing the rapidity of evaporation.† Again no evaporation can take place in a space

FIG. 100. FIG. 101.

Evaporation.

already saturated with the vapor of the same liquid; hence the rapidity of evaporation is influenced according as the surrounding atmosphere is more or less charged with the same vapor. If we direct a current of air over the surface of the fluid, we remove these vapors, thereby facilitating the rapidity of evaporation.

* See Vacuum Apparatus.

† At barometric pressure of 760.00 Mm. 1 atmosphere, the boiling point of distilled water is 100° C.

"	"	88.74	"	"	"	50° C.
"	"	23.10	"	"	"	25° C.
"	"	5.06	"	"	"	0° C.

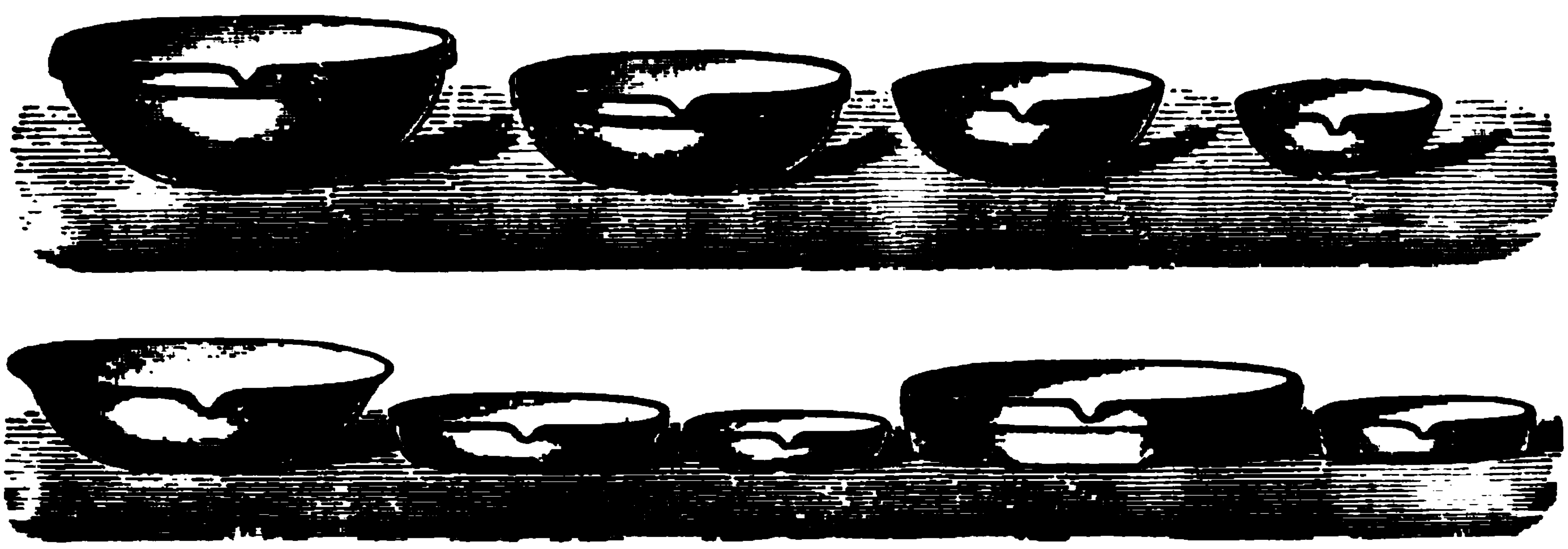
With tension of 1 atmosphere the boiling point of distilled water is 100° C.

"	"	15 atmospheres	"	"	200.5° C.
"	"	100 "	"	"	311.4° C.

With this end in view, various forms of apparatus have been devised. Figs. 100, 101, illustrate a very simple and old mode of creating a current of air during evaporation. By means of a clamp, the funnel is held inverted over the evaporating dish, the vapors rising upward through the funnel, and, like a smoke-stack, cause (by suction) a current of air to flow in over the surface. In Fig. 100 the edge of the funnel is curved inward, forming a trough to collect any vapors that may be condensed, thereby preventing them from running back into the fluid. Fig. 101 consists of a plain funnel with a glass tube fitted into the neck by means of a cork, the lower end extending close to the surface of the liquid.

5th. **Nature of the vessel and surface.** Evaporation proceeds more rapidly with less degree of heat, in vessels of copper, platinum, iron, tin, etc., than in those of porcelain or stoneware, because of the greater heat-conductivity of the former. If the inner surface of the vessel be rough, corrugated, or uneven, more

FIG. 102.



Evaporating and Crystallizing Dishes.

surface is exposed to the source of heat, imparting therefore a greater amount of heat to the fluid, thereby facilitating evaporation. In a glass vessel of smooth surface, the temperature of water may rise to 105° C. before boiling, because the water becomes superheated; if, however, a piece of broken glass be placed in the vessel, ebullition will proceed rapidly and quietly at the usual temperature of 100° C., the sharp edges of the glass acting mechanically, in assisting the disengagement of heat bubbles.

EVAPORATING VESSELS.—Porcelain dishes are best suited for the general uses of the apothecary. They should be as shallow as possible, as illustrated in Fig. 102. The last four, flat-bottomed, are intended as crystallizing dishes. Because of their fragile nature, to avoid injury to either the vessels or the substance, they are best heated on a steam, water, oil or sand bath. Where it is necessary to heat directly, the precaution should be taken carefully to dry the outside of the vessel, then to place on a wire

gauze (Fig. 103), and to begin heating gradually. When heated over a naked flame, porcelain cracks readily if the residue is allowed to set or cake in the bottom; hence, in evaporating any saline solution, we should always carry on the operation on a bath, thereby not only avoiding the danger of breaking the dish, but also the sputtering of the boiling liquid and decrepitation of the drying salt. Enameled sheet iron dishes (agate ware), are very useful and lasting; they should be discarded should the enamel chip off inside. Copper and earthen vessels are employed only by the manufacturer for larger operations. In many chemical and pharmaceutical operations, it should not be forgotten that the material of the evaporating vessel exercises considerable influence on the liquids to be heated. Distilled water, when boiled some time in glass vessels, dissolves appreciable quantities of this material, owing to the formation of soluble silicates. The particles dissolved, consist chiefly of potassa, or soda or lime, in combination with silicic acid. A much larger proportion of glass is dissolved by water containing caustic or carbonated alkali. Traces of copper are generally found in extracts which have been evaporated in copper vessels.

FIG. 103.

Evaporating over Direct Flame.

FIG. 104.

Evaporating with Properly Regulated Flame.

FIG. 105.

Evaporating Flame Unnecessarily High.

VACUUM APPARATUS—(Distillation under Diminished Pressure).—The boiling point of a liquid is materially lowered by the

removal of atmospheric pressure (page 74). We find a practical application of this fact in the "Vacuum Apparatus." It is of the greatest value in pharmacy, for the rapid concentration of certain solutions, chiefly of organic substances, such as the preparation of solid extracts. By means of this, we not only increase the rapidity of evaporation, but avoid injury to the sensitive plant principles by the lower degree of heat employed

Fig. 106.

Pharmaceutical Vacuum Apparatus.

and absence of the oxidizing influence of the atmospheric air. Fig. 106 illustrates a small vacuum apparatus for the use of apothecaries. Its construction and use is exceedingly simple. The copper vessel A, serves as a water or steam bath; in this is suspended a porcelain or copper evaporating dish, which is covered with a glass dome B made air-tight by means of a rubber joint; the thermometer is inserted at C, the air is exhausted from the apparatus by means of the water-pump

E, the glass vessel D serves as receiver, and this is closed by a metallic lid to which is attached the indicator F, enabling the operator to control the vacuum. Fig. 107 illustrates a sectional view of a vacuum pan of modern construction, such as is employed in the industries in the evaporation of sugar solutions, or the preparation of extract of beef or of condensed milk.

RAPID EVAPORATION.—Besides the usual methods of facilitating evaporation as already mentioned, another deserves mention, and that is the method of evaporation by the application of heat *over* the surface of the liquid. This method is applicable to all non-

FIG. 107.

Vacuum Apparatus (Sectional View).

inflammable liquids such as are not injured by heat. Fig. 108 illustrates Hempel's method, in which a flame burns directly above the surface of the liquid, the entire apparatus being enclosed in a cylindrical glass vessel, which is connected with a pump, for the rapid removal of the vapors and gases. Another method, is that of the Government laboratory of the Netherlands. The apparatus consists of an iron plate standing on four legs; near each corner is an opening, through which the tubes of four Bunsen burners are adjusted to such a height that their tops will be a little higher than the edge of the capsule, which is placed on the iron plate. A second plate is then adjusted over the burners. When the four flames are lit, the upper iron plate causes the flame to spread out along the plate, the direct flame and radiation of heat causing a rapid evaporation to take place. In evaporating inflammable liquids on the water bath, it is best to surround the flame by a

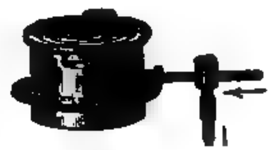
wire gauze (Fig. 109), to prevent any danger of the liquid or vapor igniting.

For evaporating or concentrating small amounts of very volatile solvents, such as ether, carbon disulphide, or petroleum-ether, it is best to place the vessel in a drying closet or desiccator, or under a bell jar which contains an absorbent, such as sulphuric acid, burnt lime, etc. For when we allow these fluids to evaporate in the open air, owing to the lowering of temperature, and the rapidity of evaporation, water is condensed on the sides of the vessel and contaminates the residue. Evaporating vessels of perpendicular sides should be employed for volatile fluids containing solids in solution, as such liquids tend to crawl up over the edge of the dish and deposit solid matter on the outside.

FIG. 108.

Hempel's Evaporator.

FIG. 109.



Bath for Evaporating Inflammable Liquids.

In evaporating liquids which give off irritating or corrosive vapors or gases, the operation should be carried on in a "Draught Chamber" (Fig. 110). This may be built into a chimney-flue or immediately in front of it, the flue leading off from the top of the chamber as shown in Fig. 111. A gas flame above, serves to create a strong, steady draught. The chamber may be arranged as shown in Fig. 110, where the draught chimney extends up one side of the chamber, there being an opening below, where the gas may be lit. Above, near the top, is a similar opening which serves to remove all gases. In absence of such arrangements, we can remove noxious vapors by inverting a large glass funnel over the evaporating liquid, it being held in position by means of a clamp over the neck, a rubber tube being attached to the end of the stem, and the other end of the tube being led to a water pump. The suction produced will carry off all traces of noxious vapors.

In evaporating such liquids as contain salts in solution, it is necessary to stir constantly, for, as they become concentrated, a saline scum forms upon the surface, which prevents further evap-

oration. Those liquids which form a scum or skin on the surface (for instance, milk), or frothy solutions, should be mixed with washed sand or pulverized glass and then constantly stirred while evaporating.

SPONTANEOUS EVAPORATION.—Water, and many other liquids, will evaporate without the application of heat, simple exposure to the air, with as large an area of surface as possible, being all that is necessary. We apply this method of concentration to those liquids which contain bodies that are injured by any degree of

FIG. 110. FIG. 111.

Draught Chambers.

heat, also for the slow vaporization of solutions of crystallizable bodies, so as to obtain well formed crystals. Instead of placing these vessels in the open air, we sometimes place them in a drying closet (Fig. 172), always taking the precaution to cover the vessel loosely with muslin or filter paper, to prevent particles of dust from dropping into the fluid. We sometimes carry on slow evaporation, by placing the dish on a tripod and setting this upon the flat top of a stove or over a hot-air radiator.

BATHS.—For general purposes of evaporation we employ various baths, in order that we may control the temperature of evaporation. Sometimes it is necessary to subject a liquid to a prolonged

FIG. 112.

Copper Water-Bath.

FIG. 113.

Iron Water-Bath.

FIG. 114.

Iron Water-Bath with Constant Level.

high degree of heat; again in others it is necessary that the temperature should not rise above a certain limit. For the purpose of regulating the degree of heat, we use various liquids of different

FIG. 115.

Water-Bath with Constant Level (Kekulé).

FIG. 116.

Water-Bath with Constant Level.

boiling points. The most common of these is water (used in the water-bath), by means of which we reach a temperature of about 97° C.

THE WATER BATH.—This is generally constructed of copper or iron, with round or flat bottom, as shown in Figs. 112 and 113.

FIG. 117.

FIG. 118.

Water-Bath (Landolt).

Steam Evaporating Kettle.

These are provided with a set of concentric rings, which enables them to be used for dishes and flasks of various sizes. In order

FIG. 119.

Iron Sand-Baths.

to avoid the inconvenience of constant watching, to prevent them becoming dry, the water bath with "constant level" (Figs. 114, 115, 116) is preferably employed. In this, the water enters through *B*, flows through the horizontal tube *C* into the bath; this, when filled to a certain height, causes an overflow in *B* which is drawn off by *A*. By connecting this with a hydrant, the supply of water can be automatically regulated. Fig. 116 illustrates another design in which the water is supplied from a self-regulating flask. Fig. 118 illustrates a large copper

FIG. 120.

Filling Sand-Bath.

bath heated by a steam jacket; this is adapted for evaporating large quantities of liquids, as in the preparation of extracts.

Baths of Saline Solutions are occasionally employed in operations where we desire a certain regulated temperature, without the precaution of a thermometer. The boiling point of distilled water is 100° C. (212° F.), but if we add any inorganic salt, the boiling point will be raised in proportion to the quantity and nature of the salt added. If we form saturated solutions we find their boiling points constant. The following table gives the temperature obtained by boiling saturated solutions of

	C.	F.
Sodium Sulphate,	100.5°	213.5°
Copper Sulphate,	102.°	213.6°
Sodium Borate,	105.°	221.0°
Sodium Chloride,	106.°	222.8°
Ammonium Chloride,	112.°	233.6°
Sodium Nitrate,	117.°	242.6°
Sodium Acetate,	122.°	251.6°
Calcium Chloride,	141.°	285.8°
Zinc Chloride,	160.°	320.0°
Zinc Chloride, Fused,	700.°	1292.0°

Fig. 121.

Tripods.

The Oil-bath is intended for temperatures not rising above 250° C. (482° F.). For this purpose paraffin is best adapted, since most fixed oils evolve very unpleasant odors when heated. Glycerin may be employed for temperatures up to 165° C., (329° F.).

A Sand-bath (Fig. 119) consists of an iron vessel with either round or flat bottom, which is filled with clean, dry sand. The vessel to be heated is partly embedded in the sand and the entire apparatus placed on a tripod (Fig. 120) and heated. We employ the sand-bath where we desire to heat a body to a high temperature; it also prevents a too rapid rise or fall of temperature, which might fracture the vessel. Sea-sand answers best for this purpose, but it should be well washed and dried before use. Not more than a $\frac{1}{4}$ inch layer of sand should be between the bottom of the vessel and the flame.

FIG. 122.

Fleck's Air-Bath.

*Air-bath.**—"Dr. H. Fleck recommends the simple air-bath, illustrated by Fig. 122, which has been in successful use for several years, doing all the duty of a water-, oil-, or paraffin-bath. By a circular cut, or other means, glass rings are prepared from cylinders of various sizes. These rings, from 2 to 10 Cm. in height, are set upon an iron plate, and covered with a similar one, having suitable openings for receiving a thermometer and the vessels intended to be set upon it. If high temperatures are required, low cylinders (of about 2 Cm. in height) are selected; low temperatures require higher cylinders (5 to 10 Cm.). The cylinders are scratched with a diamond, in a vertical direction, so that, if they should crack, the fracture would always be up and down. This simple apparatus permits the maintenance of constant temperatures of 50 to 300° C. (122 to 572° F.) and over. Its transparency is an additional advantage, when it is of importance to watch the progress of reactions, as often happens, in synthetical experiments."

* As described in the "Proceed. Amer. Phar. Ass'n," 1882, p. 53.

CHAPTER VI.

DISTILLATION.

Distillation is a process whereby a liquid, by means of heat, is converted into a vapor, and this in turn condensed to a liquid by

FIG. 123.

Simplest Form of Distillation.

means of a properly arranged cooling apparatus. This process is resorted to as a means of purification, or for the separation of

FIG. 124.

Distillation (Improvised Condenser).

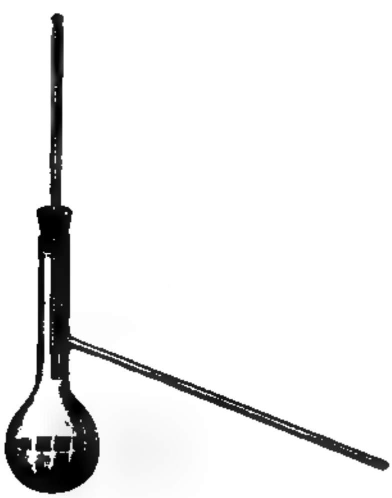
the more volatile from less volatile liquids, or it is sometimes employed as an economical and safe method of evaporation.* The apparatus (Fig. 125) consists of a *distilling flask* (or *retort*) *A*, in which the fluid is heated; the cooling apparatus *B*,

FIG. 125.

Distillation.

condensed, is called the *condenser*, and the *receiver C*, which serves to collect the condensed liquid. The distilling flask may

FIG. 126.



Fractionating Flask with Thermometer.

FIG. 127.

Flask with T-Tube for Fractionating.

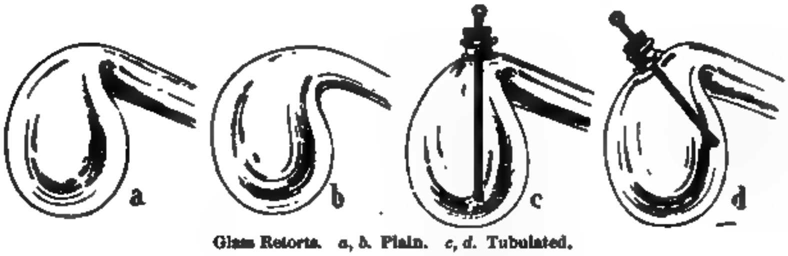
be either a retort as illustrated in Fig. 123, or an ordinary flask fitted with a bent tube serving as a beak (Fig. 125), or we may employ the "*fractionating flask*" (Fig. 126), which admits the use

* See Vacuum Distillation, page 76.

of a thermometer, the projecting side tube being connected with the condenser.

Retorts are either closed as illustrated in Fig. 128, *a*, *b*, or pro-

FIG. 128.



Glass Retorts. *a*, *b*. Plain. *c*, *d*. Tubulated.

vided with tubulures as in *c*, *d*, through which liquids may be introduced, and a thermometer or safety tube inserted. This tubulure must be so placed, that the thermometer or safety tube may stand erect and not come in contact with the sides of the retort. The retort must be bent *in* sharp at the throat, without, however,

FIG. 129.

Filling Retort.

FIG. 130.

Earthenware Retorts.

narrowing the tube (see Fig. 128, *a*). The form *b* should not be used, because, in boiling, the fluid is liable to be carried over mechanically. Fig. 128, *d* illustrates a poorly placed tubulure. Besides glass retorts, we find them made of porcelain, earthenware, iron, lead, copper and platinum.

FIG. 131.

Lead Retort.

Condensers.—Fig. 132 illustrates the most simple form of the so-called "Liebig's Condenser," which consists of a long glass tube surrounded by another of larger diameter, but somewhat shorter. At either end of the larger outside tube, is inserted a perforated cork,

which serves to hold the inner tube and admits a short bent tube at both ends, serving for the admission and discharge of water which circulates in the space between the smaller and larger tubes. Figs. 133, 134, 135, illustrate other forms, in which the openings for water are made in the upper and lower ends of the outer tube.

Another form is that in which the inside condensing tube consists of a spiral; this offers a very large condensing surface, which is necessary in distilling volatile liquids, such as ether or carbon disulphide. Fig. 136 illustrates the "*worm condenser;*" these are made of glass or metal. When of metal, the condensing pipe should be of block tin or copper; it is cooled by means of water or a mixture of salt and ice. For other forms of condensers, see Pharmaceutical Stills.

FIG. 132.

Liebig Condenser.

FIG. 133. FIG. 134. FIG. 135.

Liebig Condenser (Various Forms).

When the boiling point of the liquid is above 150° C., it is only necessary to employ an air cooler, which consists of a straight tube of large enough diameter to slip over the tip of the distilling flask, as in Fig. 137.

The *Receiver* is that vessel into which the distillate is discharged. For this purpose we employ flasks or beaker glasses. The tip of the condenser should reach inside of the receiver, and these connections should, if the liquid is volatile, be as tight as possible, making allowance however, for the escape of air.

Adapters are conical or tapering tubes of glass, which are

intended to be attached to the extremity of the condenser for conveying the distillate into the receiver, or for attaching the retort or flask to the condenser (Figs. 142, 143).

Pinch-cocks.—For the purpose of regulating the flow of a liquid or gas through a rubber tube, we employ the *pinch-cock* (Fig. 138); *b* illustrates the usual form, which is intended for closing a tube entirely; *c* and *d* can be regulated by means of a thumb-screw, hence they are better adapted for general use. The form illustrated in Fig. 139 recommends itself, in that it can be quickly applied or removed from a rubber tube, without breaking a joint; and by means of the thumb-screw, the flow of gas or water can easily be regulated.

FIG. 136.

Distilling Apparatus with Worm Condenser.

In the fitting up of apparatus, some attention must be given to the cutting and bending of glass tubing. Heavy tubing should not be used, except in special instances where strength is specially desired.

Cutting.—Glass tubing is cut by means of a triangular file or a hardened knife edge. Make a single well defined scratch or cut

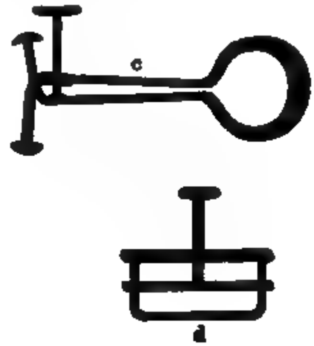
FIG. 137.

Distillating with Air Condenser. *a.* Distillating Flask. *b.* Air Condenser. *c.* Receiver.

across the surface, then grasp the tube on each side of the cut, (Fig. 144) with thumbs opposite, and carefully tap on the edge of

a table. With tubes of larger diameter or of very thick walls, the file cut should extend at least half around the tube. When the file or knife fails to cut properly, moisten with water or oil of turpentine. When it is necessary to break off a short piece, near the end of a tube, hold the shorter portion in a towel to protect the hand from accidental cutting. The rough ends of tubing should always be rounded off by holding (rotating) them in the Bunsen flame.

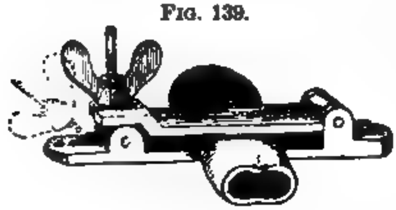
FIG. 138.



Pinch-cocks.

Bending Tubing.—Tubing is best bent in the wide gas-flame, holding it horizontally, and rotating slowly and continually so as to heat the tube uniformly on all sides. As soon as the glass begins to soften, hold it steady, and allow it to slowly bend to the desired angle, as shown in Fig. 145. In bending a tube, force must not be used, the tube must be carefully and equally heated on all sides, otherwise the angle will be unevenly bent or collapse (Fig. 146, *b*, *c*). A poorly bent angle may be restored by softening it in the flame and then blowing into the tube gently, having closed one end with a cork.

FIG. 139.

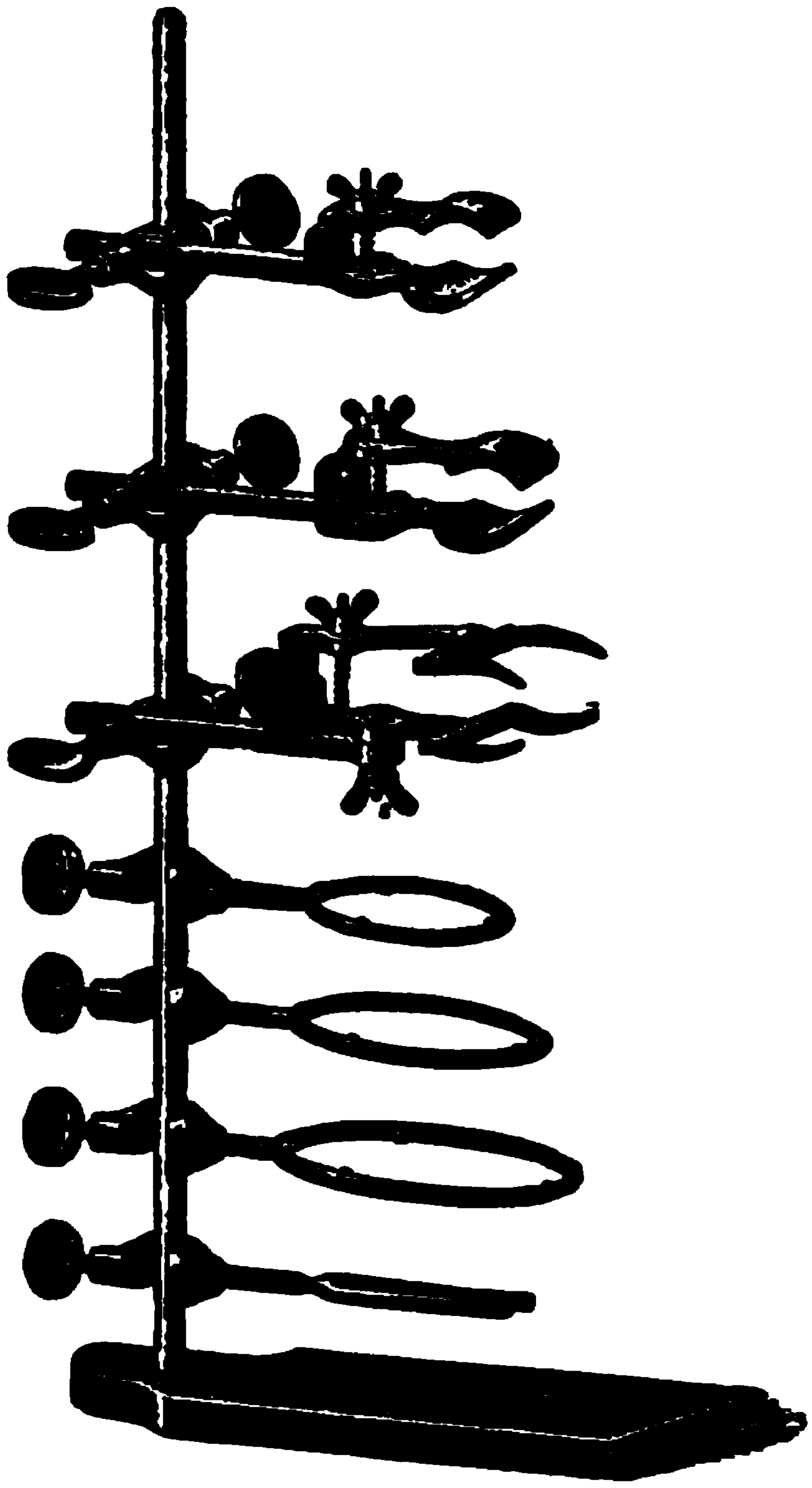


Adjustable Pinch-cocks.

Drawing out of Tubing.—It is often necessary to draw a tube out to a fine point for use in the wash bottle (also called "spritz bottle"), or for making a capillary tube for melting point determinations. The same precautions should be observed here in regard to heating, as above stated; then, when the glass is sufficiently soft, the tube should be drawn out slowly to the desired length, constantly rotating.

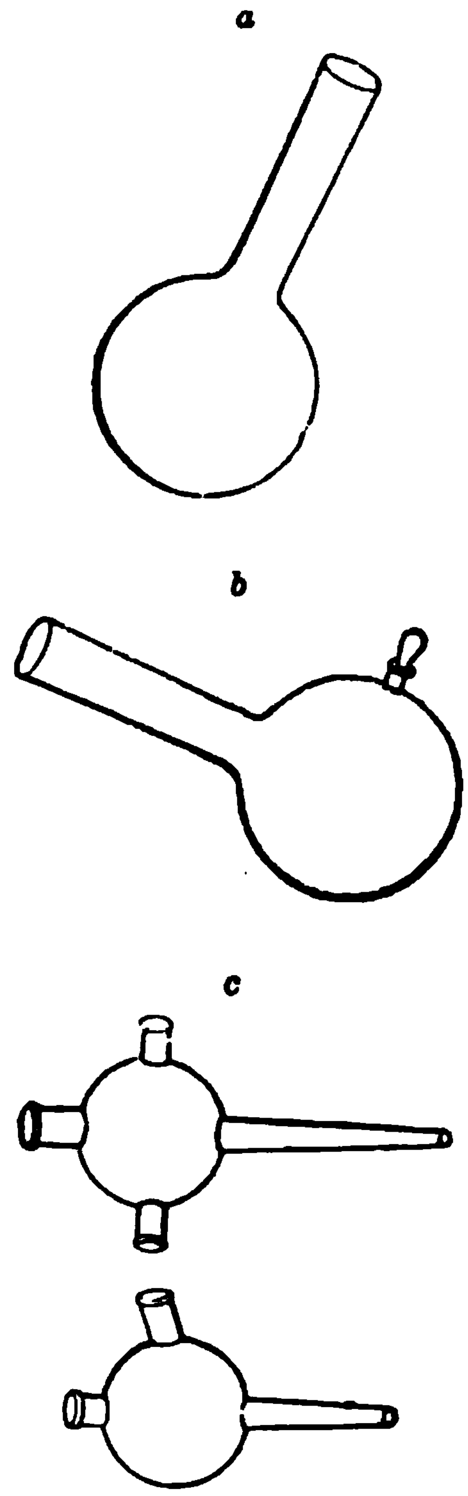
Fitting Joints.—For fitting the joints of apparatus, the best velvet corks should be employed. Rubber stoppers are still better, as

FIG. 140.



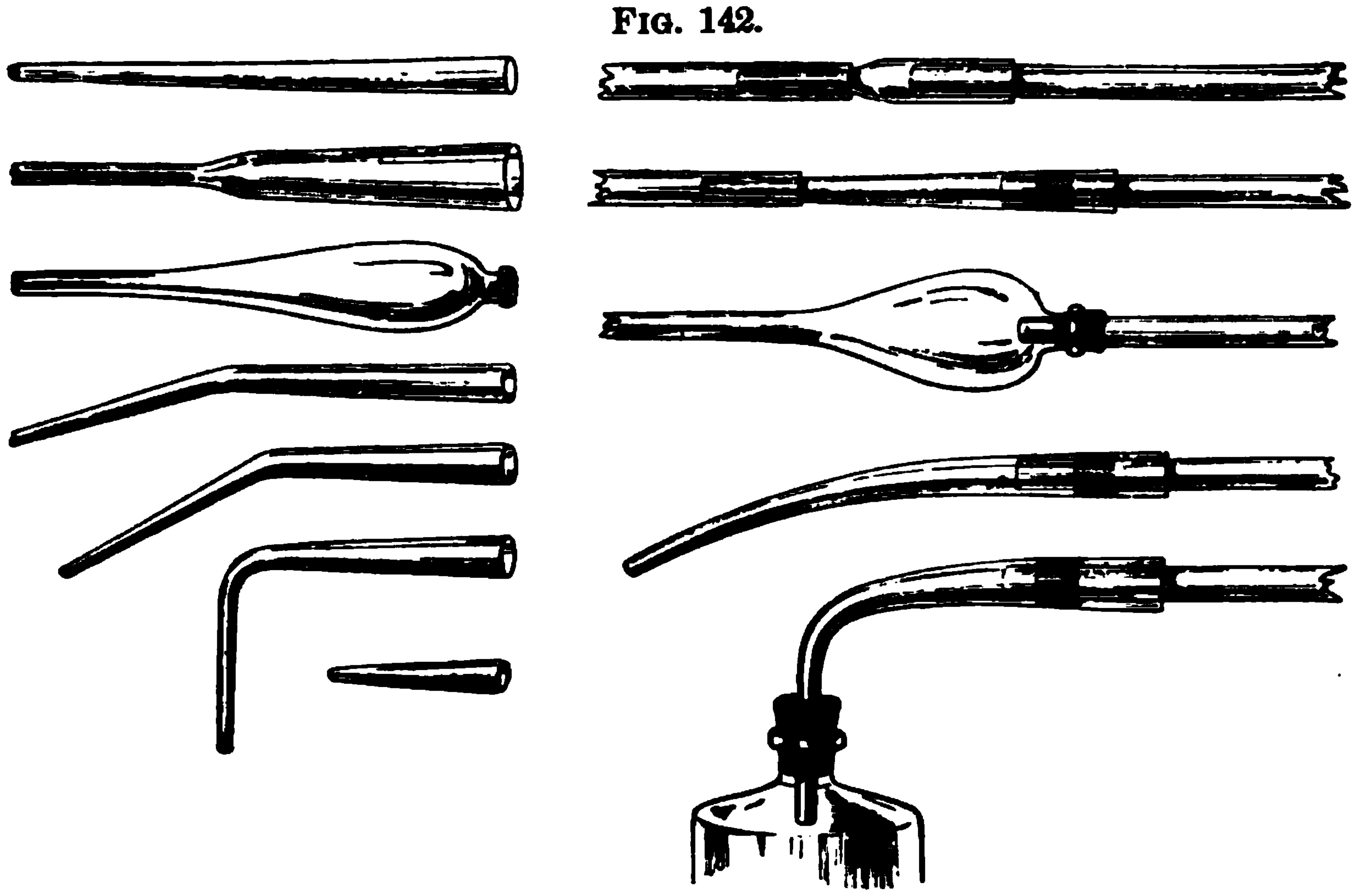
Retort Stand.

FIG. 141.



Receivers. *a.* Plain. *b.* Tubulated. *c.* Quilled.

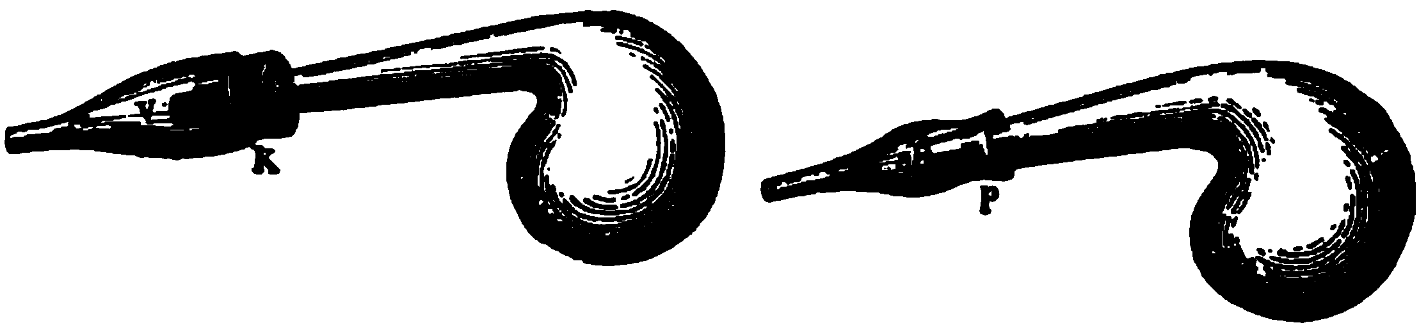
FIG. 142.



Adapters (Various Forms).

they give a very secure joint, impervious to acids and gases. But rubber should not be employed where it might come in contact

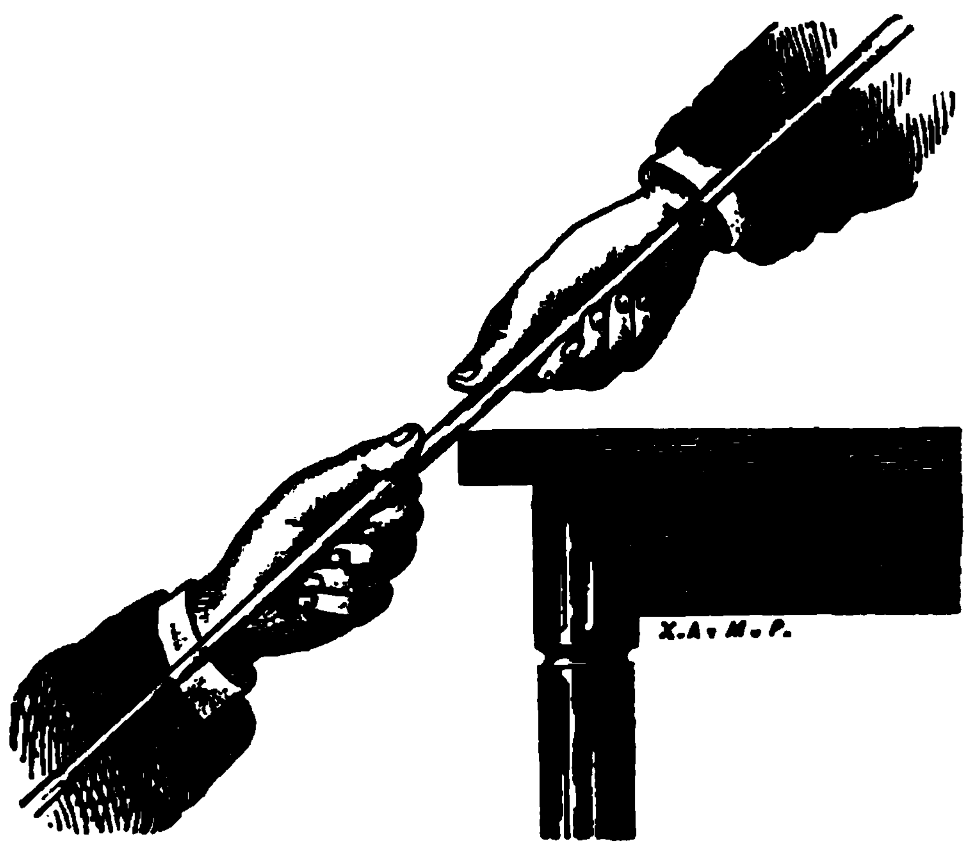
FIG. 143.



Retorts with Adapters.

with such solvents as chloroform or carbon disulphide. Corks, before being used, should be gently pressed and softened, then

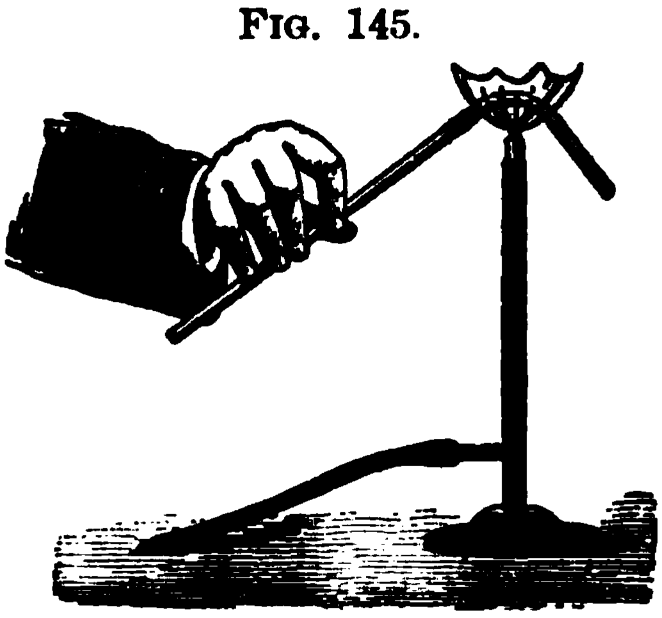
FIG. 144.



Position for Breaking a Tube.

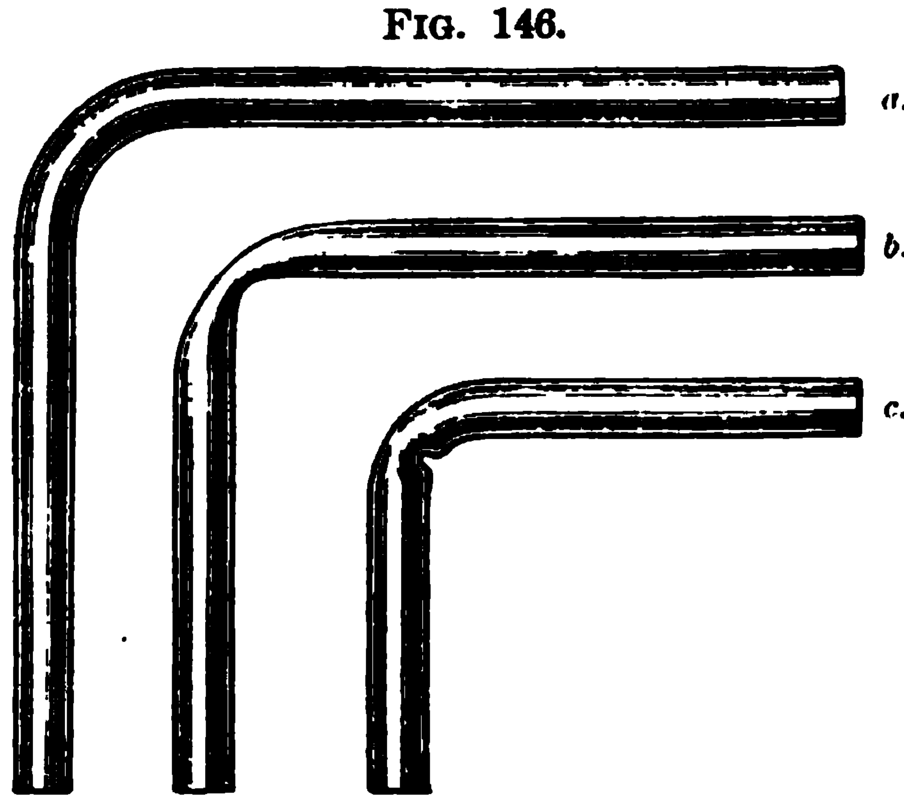
perforated by means of the *cork borer* (Fig. 147). Cork borers are brass cylinders, the lower edges of which are sharpened, the

FIG. 145.



Bending Tubing.

FIG. 146.



Properly and Poorly Bent Tubing.

milled heads affording a firm hold. When dull, the edges are readily sharpened on a whetstone or by a file. In boring a cork, place it on a block of wood, then with a tube of the desired size, moistened with water, push through with a twisting motion, taking care to keep the instrument perpendicular. In boring through a thick cork, the bored portion is apt to break off, before the borer is through. If this happens, the borer should be withdrawn, cleared of the broken piece, then wetted and reinserted, when it will readily cut its way further. Never try to bore a hole by starting it from both sides; it will rarely come true. In piercing rubber stoppers, the end of the tube should be moistened with alcohol or oil of turpentine. When we desire to connect two tubes of equal diameter or where one just fits over the

FIG. 148.

FIG. 147.

Mohr's Cork-borer.

Cork-File.

other, it is best to slip a short piece of firmly-fitting rubber tube over the joint; this will render it air-tight and secure.

Inverted or Upright (or Reflux) Condenser.—When it is desired to subject a substance to the action of a boiling liquid solvent, we

FIG. 149.

Lever Cork Press.

FIG. 150.

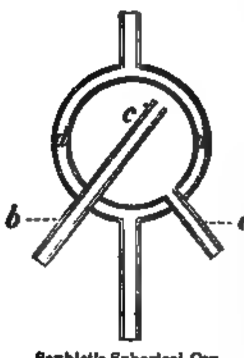
Rotary Cork Press.

employ a flask with *inverted* condenser, arranged as shown in Fig. 151. The flask is heated on a water,- sand- or oil-bath, or over the free flame, according to the nature and boiling point of the solvent. Fig. 152 illustrates a Soxhlet's *spherical* condenser, which possesses the great advantage of occupying a very little space. The cold water enters at *a* into the condensing space *c*, flowing out through *b*. The vapor enters in from below, circulates around and condenses in the space *d*.

FIG. 151.

Flask with Upright or Reflux Condenser.

FIG. 152.



Soxhlet's Spherical Condenser.

Distillation in a Current of Steam.—This is applicable to such substances as are injured when heated or distilled alone, as the volatile oils or organic bases; we also employ it in the separation of volatile from non-volatile bodies. The substance is placed in the distilling flask *d* (Fig. 153) with a little water, then steam (generated in the can *a*) is blown through. This carries the volatile matter over, to be condensed in the cooler *e*. Distillation is usually continued until oily globules cease to be driven over.

Fractional Distillation is the separation of a mixture of liquids of different degrees of volatility, by means of distillation. Mixed volatile liquids have no constant boiling point. The complete separation of two liquids, which boil at different temperatures, can only be carried out easily when the

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FIG. 158.—Apparatus for Distillation in Current of Steam.
a. Can in which steam is generated. *b.* Safety valve. *c.* Exit tube for steam. *d.* Distilling flask. *e.* Condenser.

middle fractions have been separated into the higher and lower boiling constituents. Thus, for instance, on distilling a mixture of two liquids, their boiling points being respectively 100° C. and 150° C., the liquid of lower boiling point does not come over alone at 100° C., nor the higher alone at 150° C., but the thermometer gradually rises from 100° C. up, and we obtain a mixture of both liquids, in different proportions. In this case, we collect that

portion which comes over between 100° and 110°, which consists almost entirely of the lower boiling fraction, then another fraction boiling between 110° and 140°, which consists of a mixture of both constituents in about equal proportions; finally, the fraction from 140° to 150°, which contains mainly the higher boiling liquid. The middle fraction (110° to 140°) is then again fractioned, the respective distillates between 100° and 110° and 140° and 150° being set aside; this is again repeated if necessary, and finally the

FIG. 154.

French Column Apparatus.

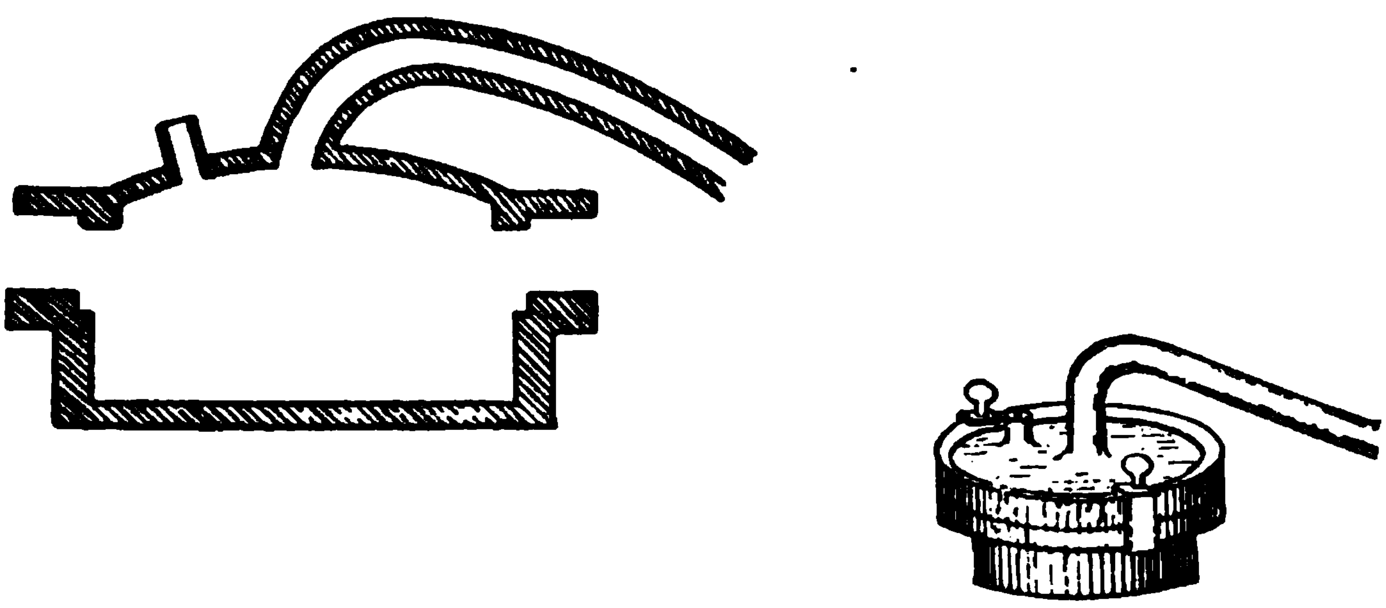
high and low boiling fractions (*i. e.*, those from 100° to 110°, and those from 140° to 150°), are in turn distilled, the receiver being changed at every 5 degrees. These products on repeated distillation in the above manner, finally yield the two pure products. For carrying on fractional distillation, the apparatus as illustrated in Fig. 84, should be employed.

Rectification is repeated distillation, whereby a distillate of

greater purity is obtained. It is employed more particularly in the recovery of alcohol from weak alcoholic liquids. Fig. 154 shows the construction of a Column Apparatus such as is employed in rectifying alcohol. It consists of a boiler (A) heated by a steam-pipe, containing the weak alcoholic liquids; the vapors pass upward through the rectifier (B), then over to the condenser (C). The highly concentrated spirit condenses in the refrigerator (D), while the aqueous portion flows by the tube (E) back into the rectifier.

Bumping.—Certain liquids, when heated to boiling in glass retorts, give rise to bumping. Ebullition may begin regularly and the distillation proceed steadily, when suddenly the liquid will become quiet for a few seconds. It then becomes superheated, and this is followed by a slight explosion of accumulated vapor, called "bumping." By the force of the explosion, quantities of the liquid are carried over mechanically, into the condenser. This bumping may be avoided or lessened, by placing pieces of

FIG. 155.



Retorts for Destructive Distillation.

broken glass in the retort, or where admissible, by suspending a string in the flask, reaching just below the surface of the liquid. These act mechanically in assisting the evolution of vapor bubbles.

Destructive Distillation is a process by which dry organic substances are subjected to heat in closed iron vessels, whereby gases, liquids, and thick tarry products are obtained. The temperature of decomposition of different substances is very different; some decompose at a temperature below 100° C., while others require a red heat. Many bodies yield entirely volatile products with no residue, while others leave a large amount of solid residue in the retort.

Amber yields Succinic Acid and Oil of Amber.
Cane Sugar, $C_{12}H_{22}O_{11}$, yields Caramel, $C_{12}H_{18}O_9$, and water, $2H_2O$.
Salicylic Acid, $C_7H_6O_3$, yields Phenol, C_6H_5OH, and Carbon Dioxide, CO_2.

By the dry distillation of complex organic substances, such as bones, wood, or coal, we obtain a large number of products, gaseous, liquid, and tarry.

PHARMACEUTICAL STILLS.

Stills are employed by the pharmacist for the purpose of recovering alcohol or ether, or for the preparation of distilled water. They are constructed of plain or tinned copper and are not adapted for distilling acid or corrosive liquids. They are all con-

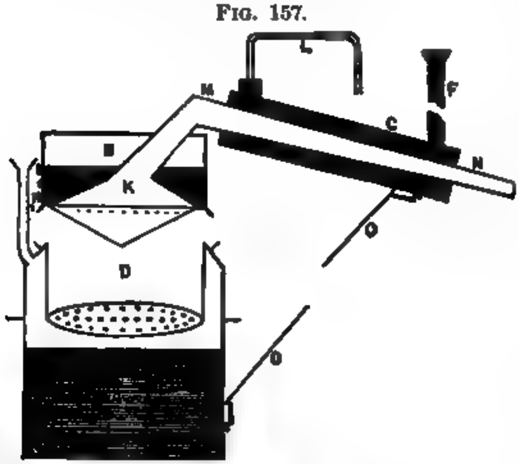
FIG. 156.

Laboratory Copper Still.

structed after the same general principle, differing, however, as to their form. The simplest form of a copper still is that illustrated in Fig. 156, consisting of a boiler surmounted by a detachable hood; a block tin worm serves as the condenser.

The *Curtman Still* (Fig. 157) is of simple construction, being specially adapted for recovering alcohol from weak percolates.

FIG. 157.



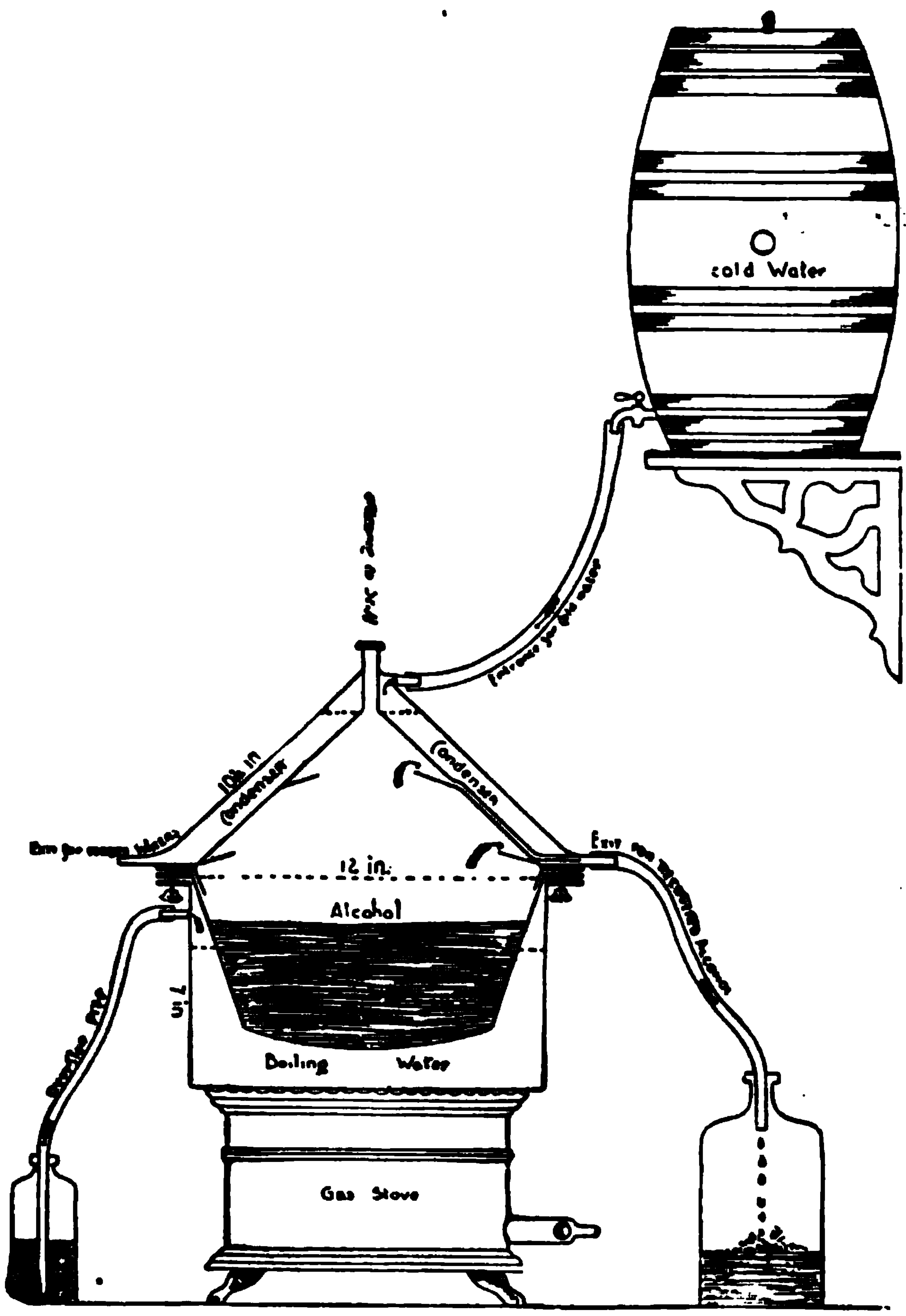
Curtman Still (Sectional View).

(A) Serves as the body of the still, (D) is a perforated diaphragm which can be placed in the still when necessary. The alcoholic vapors pass upward through the condenser (K, N). Cold water enters at (F). After circulating around the tube (N), the hea[ted] water is dischar[ged] through the tube into the still head from which it may [be] siphoned off. [The] heated water at ... serves to conden[se] most of the aqueous vapors, while the alcohol, being more ...

tile, passes over and is condensed by the colder water of the condenser. When it is desired to prepare essences, spirits or medicated waters, the necessary plant parts are placed in the diaphragm D and the steam arising from A passes through, taking up the volatile products.

Fig. 159 illustrates Edel's modified Hood Still. The condenser consists of a number (22) of cylindrical tubes, closed at the upper

FIG. 158.



Beck's Pharmaceutical Still.*

end, and fitted into the diaphragm c, c. The cold water circulates around these, thereby affording a very large condensing surface.

The Prentiss Still (Fig. 160), or alcohol reclaimer, is based on very much the same principle as the "Column Apparatus" (Fig. 154). The boiler of the still (A) has an upright column (B) screwed to it, and inside of this are a series of perforated diaphragms

* The construction of this still is so simple that an explanation was not considered necessary.

soldered to a central rod (see B, 154). The mixed alcoholic and aqueous vapors pass upward through the diaphragms, which interefere with the passage, and cause the condensation of the aqueous, while the alcoholic vapors pass on through C into the

FIG. 159.

Edel's Hood Still.

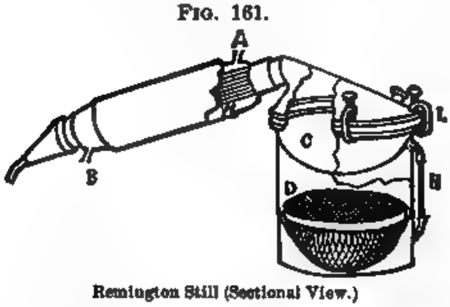
FIG. 160.

Prentiss Still.

condensing worm, being discharged at G. Cold water enters at E and is discharged at spout F.

Fig. 161 illustrates the *Remington Still.* The body of the still is made of tinned copper, the bottom being flat. The top is surmounted by a flat brass ring, upon which fits a like ring which is soldered to the still top or dome, which is held in position by the clamps L. The opening in the still dome, which is drawn over to one side, is terminated by a brass collar, over which the end of the condenser fits. The condenser, which is but a foot in length, is the special feature; this consists of seven parallel block-tin tubes, enclosed in a copper cylinder. At each end of this cylinder is a short tube, which serves for the inlet and outlet of cold water.

FIG. 161.



Remington Still (Sectional View.)

The cold water enters at B, and after circulating between the condensing tubes, passes out at A. Thus arranged, we have seven feet of condensing space in a very compact form. C, is a bath for evaporating small quantities of volatile liquids at a low temperature; this is clamped between the still body and still head; the body being filled with water, the waste steam escapes through three apertures in the rim of the water bath.

In the preparation of distilled and aromatic waters from plant parts, it is necessary that these substances do not come in contact with the heated sides and bottom of the still, hence the use of a wire cage (D) for this purpose.

Fig. 162 illustrates a very useful *Automatic Water Still*, the lower

FIG. 163.

FIG. 162.

Automatic Water Still.

Curran Water Still.

vessel being the boiler, the middle one the condenser, the upper one the supply tank. Of the four pipes shown, A is the steam and condensed water tube, coiled, as shown in the condenser tank full of water, and delivering distilled water at A′; B is a pipe leading from the water level in the boiler to the top of the supply tank; C, a pipe, with cork, leading from the bottom of the supply tank to the condenser tank; and D, a pipe leading from the top of the condenser tank to the bottom of the boiler. E is an opening, with air-tight stopper, for filling the supply tank; and F, a cock to draw off hot water from the boiler. After once starting the distillation proceeds automatically. The still can be operated by placing it on a gas stove or on top of a range or stove.

For the rapid and economical preparation of distilled water, the *Curran Still* (Fig. 163) is well adapted. Its principle and construction are very simple. It consists of a copper boiler A, resting in a galvanized case C, detachable at D B, which is perforated, in order to act as a flue to utilize all the heat from the gas burner, on the sides of the boiler. The vapors pass through the connecting pipe F into the worm P P, where they are condensed, being discharged through S W. H is a screw cover removable for filling or cleaning. These stills are constructed so that they may be heated by gas, gasoline or coal.

FIG. 164.

Mitscherlich Condenser.

The *Mitscherlich Condenser* (Fig. 164) is of very simple construction, and can be attached to any form of still. When the inner vessel A is twenty inches long and four inches wide, we have a total condensing surface, on the sides of B and D, of five hundred square inches. The condenser consists of an inner vessel A, suspended in an outer vessel B, a space of three-fourths of an inch being allowed between these vessels. These, in turn, rest in another vessel D, D. The vapors pass from the still through E into the space B, B, between A and D, and the condensed liquid is discharged at C. Cold water enters through the tubes R and R, passing into the bottom of the vessel; as it becomes heated, it rises and is discharged at Y and Z.

*Rice's Pharmaceutical Still** (Fig. 165). An improvement offered here consists of a block-tin worm condenser, enclosed in the cylindrical copper casing immediately above the still-head. This may be used as a reflux-condenser as well as for ordinary distilling operations; it affords also a great saving in space. "The apparatus consists mainly of two parts, the still and the head with condenser. The still is heated by steam, which enters at M, N being the exhaust-pipe. The condenser is a cylindrical copper vessel, with rounded bottom and closed top, having short tubes projecting from the

* Description taken from "New Remedies," 1877, page 245.

bottom and from the top at B and C. The cold water enters through the hose A; at C the water is discharged through the waste pipe D. The head of the still carries three tubulures, one for the insertion of the safety-tube L, another for filling the still, and the third, for the insertion of a thermometer. The condens-

FIG. 165.

Rice's Pharmaceutical Still.

ing pipe E, E carries the vapors upward to the upper end of the block-tin worm, contained in the condenser, and emerging from it at F. Halfway between F and the end proper of worm, the pipe is tapped and a branch, carrying the faucet H, leads into the still at C, where it terminates under the center of the head in the

form of an ∽, forming a trap to prevent the escape of vapors by this passage. The object of this arrangement is to cause the condensed liquid to flow back into the still as long as the faucet H is open, or to collect it outside by turning off the faucet H. Prolonged digestions with alcohol may be made by means of this apparatus, without any loss of liquid. The head is attached to the still by means of a rubber or pasteboard washer and iron clamps, and when it is desired to remove it, the water is allowed to drain from the condenser, the clamps are removed, and the whole is hoisted up by the tackle K and set to one side."

CHAPTER VII.

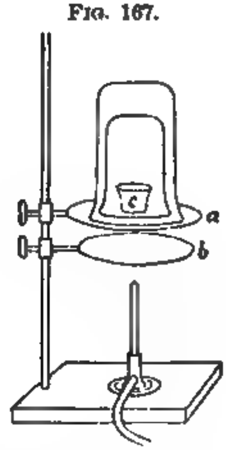
SUBLIMATION.

Sublimation is distillation applied to volatile solids. Certain solids, when heated, are converted into vapor, and this, when condensed on a cool surface, yields the substance in its solid (crystalline) but purified form, called a "*sublimate*." This process can be applied only to such solids as do not undergo decomposition on heating. Sublimation, like distillation, has for its object the separation of the volatile from the non-volatile or less volatile substances. In the first mentioned operation, the product (*sublimate*) is solid, while in the second, the product (*distillate*) is liquid.

FIG. 166.

Experimental Sublimation of Sulphur.

FIG. 167.



Oddo's Sublimation Apparatus.

The object of sublimation is therefore solely the purification of the substance. As examples we have iodine, salicylic acid, camphor, sulphur, benzoic acid, etc. We have other instances where the process serves for the formation, as well as separation of the volatile solid, as calomel, corrosive sublimate, ammonium chloride. An apparatus for conducting the operation on a small scale (Fig. 167), consists of two circular discs of asbestos *a* and *b*. The upper disc has a hole pierced through the middle, in which the beaker *c*

sits, containing the body to be sublimed. Two large beakers are inverted over this; the inside one serves for the collection of the sublimate, while the outer beaker condenses any vapors that may escape from the inside. It is well to lay two circular discs of glazed paper (with corresponding holes) under the beakers on *a*. The

FIG. 168.

Bruehl's Sublimation Apparatus.

FIG. 169.

Sublimation of Benzoic Acid (small scale).

disc *b* serves for distributing the heat. With such bodies as ammonium chloride, corrosive sublimate, and ammonium carbonate, condensation takes place at a comparatively high temperature within a small space; the substance is then deposited in compact

FIG. 170.

Sublimation of Benzoic Acid (Hager's Apparatus).

masses. When the vapors of the body are conducted into large cool chambers (Fig. 170), the sublimate is deposited in small particles (minute crystals), like that of sulphur.

Fig. 168 illustrates a very simple form of apparatus for subliming small amounts. The substance is placed in a small crucible

and slowly heated, the vapors condense on the surface of the glass globe, which on cooling, can be removed for the collection of the sublimate. Should the globe become heated, it can be kept cool by laying a cone-shaped spiral of lead pipe (cooled with water) on the surface.

Fig. 169 illustrates the old method of preparing small amounts of benzoic acid from benzoin. Benzoin in coarse powder, is mixed with dry sand and placed in a shallow tin pan, *a*; over the top, *d*, a sheet of filter paper is tied, and this is punctured full of pin holes. A hood, *c*, is made of glazed paper, fitted, and tied over the top of the pan at *d*. The apparatus is subjected to a low and uniform heat; the vapors of the benzoic acid pass up through the perforated porous cover and are condensed on the cool sides of the paper hood.

FIG. 171.

Apparatus for the Preparation of Calomel.

Fig. 170 represents the preparation of benzoic acid by sublimation. In the chamber *a*, the mixture of benzoin and sand is heated, the vapors of the acid, by means of a regulated draft, *c*, *e*, are caused to pass into, and condense in, the large chamber. The current of air follows the direction indicated by the arrows passing through *d*, *f*.

The method of the sublimation of calomel is shown in Fig. 171. In the earthenware retort, *C*, the crude calomel is heated, the vapors pass over into the stoneware condenser, *D*, where they meet a current of steam from the tube *tt*, which causes the calomel to condense and to drop into the water below. This treatment aids in dissolving out any mercuric chloride which might accidentally have been formed.

CHAPTER VIII.

DESICCATION.

Desiccation consists in depriving solids (drugs, chemicals) of moisture at a low temperature.

Pharmaceutically, its objects are the following:—

1st. *It Reduces Bulk.*—Vegetable drugs contain a variable amount of moisture,* and, in consequence thereof, are more or less bulky. If we can remove this moisture without injury to the constituents, we will gain a great advantage by concentrating their strength and reducing their bulk. For example, an opium containing eight per cent. of morphine and twenty per cent. of moisture is thoroughly dried; it will lose one-fifth of its weight, thereby increasing the relative proportion of the morphine one-fourth.

2d. *It Facilitates Comminution.*—As long as a drug or chemical contains moisture, it resists pulverization, because of the tenacity and sponginess of the drug, or the dampness of the powder, which causes it to cake. As soon as the moisture is removed, the drug becomes brittle and readily disintegrates.

3d. *It Assists Preservation.*—As long as vegetable drugs contain moisture, they are liable to become mouldy or to ferment, resulting in injury to their constituents and rendering them unfit for use. Many chemical salts have the property of rapidly absorbing moisture from the air (see Deliquescence), while others lose crystal water and fall to a dry powder on standing in the air (see Efflorescence). In either of these cases, a decided *increase* or *decrease* of weight of the salt takes place, with a corresponding increase or decrease of strength; hence, for the sake of accuracy, as well as convenience, we often resort to desiccation and pulverization of these substances.

As time is always a consideration, drugs are rarely subjected to the old process of spreading out the leaves, roots, or bark, and then exposing them to the sun, or in a dry loft.

Drugs are dried by placing them, in a coarsely comminuted condition, on wooden trays with a perforated or wire netting bottom. Chemicals are placed on trays with a muslin bottom,

---

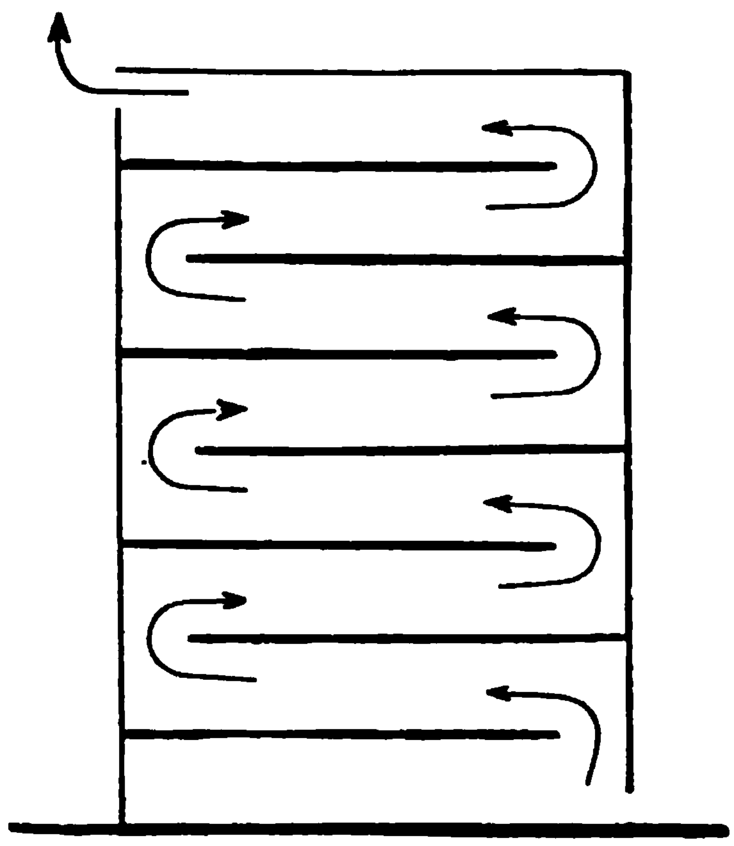
* 100 parts of freshly gathered,

	yield in dry drug about		*yield in dry drug about*
Belladonnæ Folia,	18 parts.	Calamus,	25 parts.
Arnicæ Flores,	20 "	Althæa,	25 "
Digitalis,	20 "	Glycyrrhiza,	33 "
Mentha Piperita,	20 "	Colchici Radix,	34 "
Taraxacum,	22 "	Belladonnæ Radix,	38 "
Scilla,	25 "	Stramonii Folia,	45 "
Valeriana,	25 "	Mezereum,	50 "

(Tschirch.)

these being then placed on a framework, in chambers which are heated to the necessary temperature, which varies according to the nature of the substance. The arrangement of such chambers is very much the same as in the drying closet, the principle of which is shown in Fig. 172. Each shelf or partition is so placed, that the draught of dry or heated air passes over and around it, escaping above, loaded with moisture. In some cases, the air is first passed over burnt lime to remove all moisture, before passing into the drying chamber. Drying closets may be so arranged, as to utilize the waste heat from a stove-pipe, or by passing a steam-pipe through it. The vessels containing the burnt lime, should be placed in the bottom and on the different shelves. Thus arranged, the drying closet may also be utilized for storing hygroscopic drugs and chemicals.

FIG. 172.



Drying Closet (Sectional View).

*Loss in Drying Drugs.**—The drying of drugs requires the greatest care and consideration, since many of them contain volatile and active principles, which are easily injured by the slightest degree of overheating, for example, conium leaf and fruit, aconite, etc. Aromatic drugs like cloves, nutmeg, cinnamon, cardamon, etc., are apt to suffer a loss of their volatile aromatic constituents to a greater or less degree; hence when several of these enter into a pharmaceutical preparation, it is best to grind the crude aromatics together to a powder, and not mix the several dried powders. Again, such drugs as asafœtida, myrrh, ammoniac, suffer loss of volatile oil in the process of drying and reduction to powder; hence, when powdered, they are unfit for dispensing or for the preparation of the "Mixtures." In preparing Emulsum Asafœtidæ, or Ammoniaci, or Mistura Ferri Composita, only selected tears of the several gum-resins should be employed.

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* The following drugs lose, on an average, by drying and powdering:—

Acacia,	0.8	per cent.	Ergota,	3.62	per cent.
Aloe Socotrina,	11.2	"	Gentiana,	10.23	"
Acidum Tartaricum,	1.06	"	Ipecacuanha,	1.91	"
Buchu,	2.00	"	Myrrha,	5.80	"
Cantharis,	2.05	"	Opium,	19.61	"
Cardamomum,	6.02	"	Podophyllum,	0.75	"
Cassia,	2.61	"	Rheum,	1.74	"
Cinchona Flava,	2.57	"	Scilla,	13.60	"
" Rubra,	1.58	"	Tragacantha,	6.93	"
Cubeba,	2.40	"	Zingiber (alb.)	9.70	"

(Squibb.)

Every apothecary should employ the greatest care in the selection of his powdered drugs, for the market is well provided with inert and adulterated material.

Storage and Preservation.—Considerable care must be observed in the storage of powdered vegetable drugs. They should be kept in a dry place not subject to marked changes of temperature, preferably stored in tin canisters, the tops of which are slightly perforated, so as to admit the access of air, and yet to keep out dust and insects. Wooden boxes or drawers are not suitable, for they allow the accession of mites and dust, the drug rapidly losing what odor or aroma it may possess. For storing crude drugs or roots, barks and leaves, drawers may be constructed which are lined with tin, the lids being so placed that they can only be opened when the drawer is open; these drawers answer well for storing such powders as Gentian or Columbo.

When exposed to the air, powdered drugs absorb moisture (1 to 20 per cent.), the amount depending on the hygroscopicity of the particular powder; those containing fixed or volatile oils being the least hygroscopic, while the largest amount of moisture is absorbed by mucilaginous drugs.

FIG. 173.

Copper Drying Oven.

In the course of Pharmaceutical Assaying, it is frequently necessary to dry small quantities of substances before weighing, in which case we employ the "*Drying Oven*" (Fig. 173), which is usually a single walled copper box placed on a stand. A Bunsen lamp is placed below and, by regulating the flame, the temperature in the oven may be regulated; an opening above is for the insertion of a thermometer. These ovens are also constructed with double walls to admit filling with water, when the desired temperature should not rise above 100° C. For very high temperatures, iron ovens are employed. After the operation of drying or ignition, it is necessary to allow the substance to cool in a "*Desiccator*," to prevent absorption of moisture, before weighing. If the substance has been dried on a watch-glass, then another well-fitting watch-glass is inverted over it, and the two are held firmly together by means of a spring (Fig. 176), which prevents any possible loss of powder by spilling, and also prevents absorption of moisture during the weighing. Hot crucibles are placed on pipestem wire triangles in the desiccator. Many bodies, owing to

their low melting point, cannot be dried by heat, hence we place them in the desiccator over sulphuric acid, or calcium chlo-

Fig. 174.

Copper Drying Oven (Double Wall).

Fig. 175.

Fig. 176.

Watch-glasses for Weighing Powders.

Iron Drying Oven.

Fig. 177.

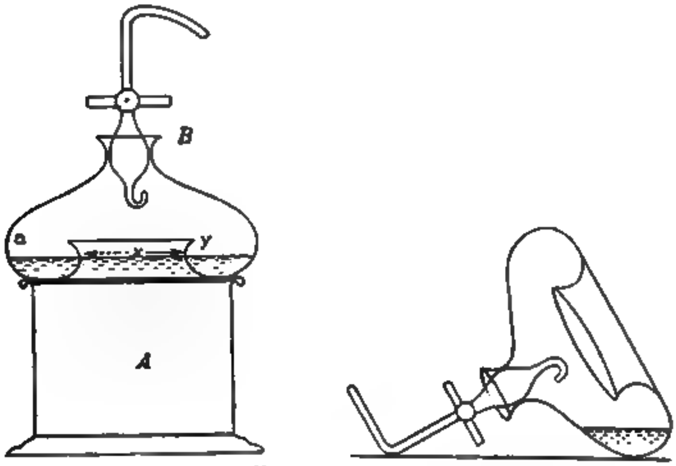
Bell-glass Desiccator.

ride, etc., where they give up their moisture readily.

Desiccators are of various forms. Fig. 177 illustrates one consisting of a bell-glass (b), with a ground rim fitting closely to the ground glass base. The vessel (c) contains the moisture-absorbing material; above this is a porcelain table (d), upon which the substance to be dried is placed. Fig. 178 illustrates a form of desiccator, designed by Hempel, the principle of which consists in placing the absorbing material (H_2SO_4) in the rim of the cover (*a–y*), *above* the

substance which is placed in the lower vessel *A*. The cover is provided with a tube and stopcock, which fits into the neck at *B*,

FIG. 178.



Hempel's Desiccator.

for connecting with a suction-pump if necessary to dry "in vacuo." Fig. 179 illustrates another form, provided with a stopcock *a*, which may be placed in connection with a vacuum-pump and the air exhausted. The ground edges of the fittings should be greased with a little fat or petrolatum.

FIG. 179.

Vacuum Desiccator.

As material for the absorption of moisture (water), for use in desiccators, we employ usually either sulphuric acid or granulated calcium chloride; besides these we may also employ either calcium oxide (burnt lime), fused caustic potash or soda, or phosphoric oxide (anhydrous phosphoric acid).

Drying Liquids.—For removing small amounts of water from such liquids as alcohol, ether, ethyl nitrite, chloroform, volatile oils, we employ fused calcium chloride, sharply-dried potassium carbonate, or anhydrous copper sulphate. Care should be taken not to employ any substance which may react chemically on the liquid to be dried, for instance, calcium chloride cannot be employed in drying wood alcohol, benzyl alcohol or many esters, because it unites with them, forming crystalline compounds. Absolute alcohol is prepared from ordinary alcohol, by percolating it

through burnt lime, which effectually removes all but traces of water.

Fig. 180.

Gas Wash Bottles.

Drying Gases.—For drying (washing) gases, we employ the various forms of "wash bottles" (Fig. 180), in which the gas

Fig. 181. Fig. 182.

Drying Tube (Chloride of Calcium). Drying Jar (Chloride of Calcium).

passes through a layer of sulphuric acid; the tube through which the gas enters the flask, should dip from one-half to

three-quarters of an inch below the surface of the acid. Figs. 181 and 182 illustrate another method of drying gases, in which the gas is passed through either a U tube, or upwards through a glass jar or tower, filled with granulated calcium chloride. A wad of absorbent cotton or spun glass wool is placed in the neck (Fig. 182), upon which the granulated calcium chloride rests, and another layer is placed on top just beneath the cork.

GENERATING GASES.—

For the generation of gases, such as chlorine, sulphur dioxide, ammonia, etc., an apparatus, such as is figured on page 131, is usually employed.

When it is desirable to have a ready supply of gas available, such as carbonic acid gas, sulphuretted hydrogen, hydrochloric acid gas, chlorine, etc., the Kipp gas generator is the most convenient. The construction of this apparatus is shown in Fig. 182 A. Into the reservoir *a* the acid to be employed in generating the gas, is poured; this flows into the vessel *d*, below, until it rises and comes in contact with the solid material *b*, from which the gas is generated; the contact of the acid with the solid causes the rapid disengagement of gas, which, if not allowed to escape at *e*, forces the acid down and back into the reservoir *d* and *a*, further reaction between the solid and acid ceasing. When a supply of gas is desired it is only necessary to open the stopcock at *e*, this removes the pressure below and permits the acid to remain in contact with the solid material, affording a constant current of gas. For the generation of carbonic acid gas, small pieces of marble are placed in the apparatus at *b*, and dilute hydrochloric acid is employed as the acid solution. For generating sulphuretted hydrogen, iron sulphide in coarse lumps and dilute sulphuric acid may be used. For generating hydrochloric acid gas, ammonium chloride in lumps and concentrated sulphuric acid are employed.

FIG. 182 A.

Kipp's Gas Generator.

CHAPTER IX.

COMMINUTION.

The collection, drying, comminution and subsequent pulverization of drugs is at present seldom, if ever, performed by the retail apothecary. This branch has fallen entirely into the hands of the drug-miller. Crude vegetable drugs are first

FIG. 183.

Contusion of Drugs.

reduced to coarse particles by slicing or chopping, in order to facilitate their drying and subsequent pulverization. This is called *Comminution.* The slicing is done by means of chopping knives or rolling circular blades operated by machinery. In this comminuted condition, the drug is dried and then subjected to the operation of bruising, called *Contusion.* This consists in reducing the drug to particles by pounding or beating in a mortar (Fig. 183).

As soon as the drug has been thoroughly bruised it is ready for grinding.

GRINDING is the reduction of substances to coarse particles in properly constructed mills.

PULVERIZATION is the reduction of substances to fine particles.

The drug-miller employs a variety of mills, for the purposes of grinding and pulverizing. Among these are the Chaser, Buhr-Stone, Bogardus Eccentric, and Roller Mills, Disintegrators and other patent mills, each of which is adapted to special purposes. Since the construction and operation of these mills are of practical interest to the drug-miller only, they are omitted here.

A Hand Drug-Mill that answers the purposes of the pharmacist, must be so constructed, that it may be adjusted for all kinds of general work.

According to the arrangement of the grinding surfaces hand-mills may be divided into two classes.

1. Those in which the grinding plates are arranged *vertically.*
2. Those in which the grinding plates are arranged *horizontally.*

In all of them, the grinding plates consist of teeth arranged in concentric rows, one plate fitting into the other; the distance between the grinding surfaces being regulated by means of a thumb-screw, thereby regulating the degrees of fineness of the powder.

1. *Hand Drug-Mills with Vertical Grinding Plates.*—Among these are the Swift, Trœmner, and Enterprise mills. The latter (Fig. 184), because of the simplicity of its construction, and the ease with which it is handled and cleansed, has become very popular. In this mill, the grinding plates are supported on a horizontal shaft, which is turned by two heavy fly wheels. The shaft rests between two hemispheres, enabling the operator, after opening the mill, to remove all the working parts. The various parts can be readily removed and replaced in case of fracture. The left-hand grinding plate, being geared to the shaft, revolves, while the right-hand one is stationary. The fineness of the powder may be easily

regulated by means of a thumb-screw, which regulates the distance

FIG. 184.

Enterprise Drug-Mill.

between the plates. Various sizes are made, down to the small dispensing counter-mill.

FIG. 185.

Hance Drug-Mill (Cross Section).

2. *Hand Drug-Mills with Horizontal Grinding Plates.*—An older form is the Thomas mill; later improvements are found in Swift's B mill, in which the grinding plates are arranged horizontally, the upper one being stationary, while the lower one revolves. It can be easily opened and cleaned, the main objection being its open receptacle for the powder.

An embodiment of this same idea, but vastly improved, is the Hance conical-plate mill, in which the horizontal grinding surfaces are given a conical shape. The main feature of this mill is that the powder yielded is always uniformly fine and free from coarse particles, while the vertical-plate mills often allow these to drop through. The conical shape of the grinding plates, allows a ready discharge of the powder, thereby avoiding clogging up of the mill,

which is very often the case in those having horizontal plates. This mill is adapted for all kinds of heavy and light work and can be readily taken apart for cleaning. The lower plate is of conical shape, capped with a beaker, and fits upon the upper end of the upright shaft, and revolves with it, engaging with the teeth in the upper grinding-plate and hopper. Power is transmitted by means of two shafts at right angles, geared with bevel cog-wheels. The fineness of the powder is regulated by a thumb-screw at the base, which elevates the revolving plate.

THE FOLLOWING PRECAUTIONS MUST BE OBSERVED IN HANDLING DRUG-MILLS.—The mill, if not sufficiently heavy, should be securely bolted to a firm foundation; otherwise much of the power exerted at the wheel will be lost.

The bearings should be kept clean and lubricated.

FIG. 186.

Hance Drug-Mill (Showing Parts).

The drug should be as dry as possible, otherwise the moist particles will stick to the plates and cause clogging.

In grinding coarse, bulky or fibrous drugs, they should first be reduced to coarse particles by bruising, then run through the mill several times, first with a very coarse adjustment, then after sifting off the fine particles, returned to the mill, after the plates have been readjusted. The procedure is continued until the whole is ground to the proper degree of fineness.

The drug should not be fed into the hopper faster than it can be ground, otherwise clogging will ensue. Dry, brittle drugs, may be fed more rapidly than moist, oily ones. Very oily drugs are best ground coarse at first, the fine powder sifted off, and the tailings reground, etc.

After each operation, the mill should be thoroughly cleansed, all particles adhering to the plates being removed. Should these

have become clogged with hard lumps, the latter should be removed with boiling water, and the plates well dried. In most cases the running through of sawdust will be sufficient.

POWDERING.—In grinding and powdering some substances certain precautions must be observed by the workmen carrying on the operations, in order to avoid injury or painful affections. For instance, the dust arising from the powdering of belladonna is apt to injure the eyesight; that from cantharides acts as a vesicant; certain salts of mercury and all salts of arsenic are very poisonous, etc.

FIG. 187.

Pulverization of Corrosive or Poisonous Substances.

Some bodies cannot be pulverized alone, that is, they require the addition of a foreign body which facilitates disintegration; this method of powdering is called "*pulverization by mediation.*" We employ intermediates in powdering camphor, for, owing to its elastic nature, we cannot powder it alone; hence we moisten it with alcohol or ether, whereby it disintegrates readily. Rice is softened in water before being ground. Vanilla requires the intervention of sugar or milk sugar crystals. Centrifugal force is used for the reduction of zinc to fine powder, the molten metal being poured on a horizontal revolving plate of iron, which turns at the rate of 2000 revolutions a minute. By this means, the zinc is projected against the sides of the box in which the disc is enclosed. For the fine subdivision of phosphorus, it is melted under water, and the latter then agitated until cool. Gold-, silver-, and bronze-leaf are powdered in the presence of honey or sulphate of potassium, which is afterwards removed by washing. Nux vomica or ignatia, owing to their tough and horny structure, are first steamed, which causes them to swell and soften, after

which they are rapidly dried, and then easily reduced to powder. For powdering resins and gums, some manufacturers employ casks or iron cylinders which revolve upon an axis, and in the interior of which iron balls roll about, crushing the substance.

SIFTING

Is the process of separating powders of different degrees of fineness by passing them through some perforated medium. For this purpose sieves are employed. These consist of a frame, usually circular, over which is stretched wire- (iron- or brass-) gauze, or better hair-cloth or silk, held firmly in place by an outer rim. Drum sieves are cylindrical and covered at both ends. In attempting to sift powders by hand, only a moderate quantity of the material should be placed on the sieve at once, sufficient that when the sieve is given a horizontal shaking motion the substance will slide freely about, allowing the finer particles to fall through the meshes. No effort should be made to hasten sifting by attempting to force the material through by pressure of the hand, for by so doing, coarser particles will be forced through, thereby destroying the uniformity of the sifted powder. After use sieves should be thoroughly cleansed by tapping the edge upon a counter, then passing a stiff brush around the edges and over the meshes, inside and outside, to force out particles of the adhering powder. After sifting, a powder should always be thoroughly mixed, in order to insure uniform composition of the product When we operate upon larger quantities of powder, we have special apparatus (combined sifters and mixers) designed for this purpose. Among these, Hunter's (Fig. 188) is one of the most effective. The powdered drug or mixed powders are thrown into the hopper above, then by means of brushes, which revolve against the curved brass sieve, the lumps are thoroughly disintegrated, and the powder is brushed through into the receptacle below, where it is further mixed by revolving spiral mixers. These combined sifters and mixers are well adapted for the manufacture of baking-powder, tooth-powder, compound licorice powder, seidlitz mixture, etc. For preparing impalpable powders, bolting cloth is employed. Commercially, powders are known by numbers. The U. S. Pharmacopœia directs the employment of various degrees of fineness, designating the degree by a number, which corresponds to the number of meshes to the linear inch; the powders being numbered from 20 to 80 inclusive.

FIG. 188.

Hunter's Sifter and Mixer.

The British Pharmacopœia directs the numbers from 20 to 80 inclusive, designating them by the number of meshes to the linear inch, as in the U. S. P., omitting, however, the metric equivalents. The German and Austrian Pharmacopœias designate by the number of meshes to the square centimeter.

TABLES OF DEGREES OF FINENESS OF POWDERS, U. S. P. AND B. P.

No.		*Meshes to Linear Inch.*	*Meshes to the Centimeter.*
80	Very fine powder	80	30
60	Fine	60	24
50	Moderately fine	50	20
40	Moderately coarse	40	16
20	Coarse	20	8

DEGREES OF FINENESS OF PH. GER. AND PH. AUS.

No.		*Meshes to the Centimeter.*	*Corresponding to U. S. P.*
50	Impalpable powder	50	
40	Exceedingly fine	40	
30	Very fine	30	80
25	Fine	25	about 60
20	Moderately fine	20	50
15	Moderately coarse	15	about 40
8	Coarse	8	20

TRITURATION

Is the reduction of substances to a minute state of subdivision by means of the mortar and pestle. The pestle should be grasped firmly, and, with a slight downward pressure, worked around the

FIG. 189. FIG. 190.

Trituration. Motion described by Pestle.

bottom and sides of the mortar with a circular motion, gradually extending from the center outwards, as shown in Fig. 190. Then the motion should be reversed toward the center, in the same manner, and this procedure should be continued until the substance is reduced to the desired degree of fineness.

Mortars and Pestles.—For the pulverization of hard or tough

drugs, where considerable force is necessary, the iron or bronze mortar is employed (Fig. 191). The interior should be bell-shaped and not conical, otherwise the drug will become packed in the bottom, hindering proper disintegration. After use, they are best cleaned by triturating in them some clean sand. When they have been used for powdering chemicals, such as iron or sodium sulphate, they should be well washed and dried.

Wedgwood-ware answers admirably for general use, because of its strength, though, owing to its somewhat porous surface, it is often difficult to cleanse. Again, the handle of the pestle being of wood, it is usually set into the base by means of a resin cement; it, therefore, readily loosens and drops some of the cement off, contaminating the substance that may be triturated. The handles should be reset before using, by heating until the cement softens, then filling the pestle hole with a fused mixture of 3 parts of

Fig. 191.

Iron Mortars.

shellac, 1 of yellow wax and 1 of turpentine, pressing in firmly, holding until the wax has hardened. Handles are now made of hard rubber which screw firmly into the pestle.

Porcelain mortars and pestles are preferred for general use in the preparation of solutions, emulsions, light triturating etc. They are much more easily cleansed than the Wedgwood ware, since their inner surface is not porous like that of the latter. Porcelain mortars will not stand hard blows nor rapid heating, because of their liability to fracture. Glass mortars (Fig. 195) should likewise be carefully handled, and should not be employed for triturating hard substances. They are best adapted for pulverizing corrosive substances, chemicals, alkaloids, and for preparing solutions of the same. Their surface is smooth, and no loss of substance is liable to occur, as would be the case when using a Wedgwood mortar, whose surface is porous or uneven.

Agate mortars (Fig. 196) are only employed in pulverizing very hard substances, such as minerals or ores.

In selecting mortars and pestles, the apothecary should use considerable discretion: For general purposes of trituration a shallow mortar (Fig. 193) should be selected. For the preparation of emulsions and solutions, a comparatively deep mortar (Fig. 194) should be used. The pestle should fit the mortar accurately, that

FIG. 192.

Wedgwood Mortar.

FIG. 193.

Porcelain Mortar (Shallow).

is, a round-surfaced pestle should be used for the deep, and a somewhat flat-surfaced one for the shallow mortar.

Every apothecary should have a full set of mortars and pestles, of various sizes and shapes, adapted for all sorts of operations. It should be made a rigid rule to clean these immediately after use. When the powdered substance has been of a resinous nature, its

FIG. 194.

Porcelain Mortar (Deep).

FIG. 195.

Glass Mortar.

FIG. 196.

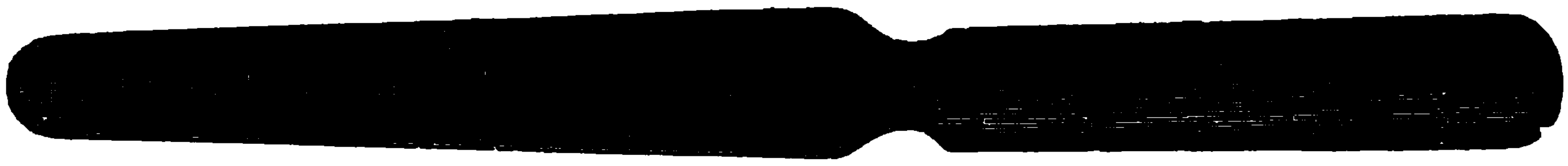
Agate Mortar.

traces are best removed by means of a little alcohol or benzin, and if it has been of an oily nature, the remaining particles may be removed with sawdust, and the mortar then washed out with soap and water. If the substance possessed a powerful odor, like that of iodoform, or the mixture has badly stained the mortar, triturate a little bichromate of potassium with sulphuric acid about the sides, rinsing out well with water.

SPATULAS.

A *Spatula* consists of a long, flexible blade of polished steel, somewhat heavier at the base, where it is usually covered on both sides with hard wood, serving as a handle. Spatulas are also made

FIG. 197.

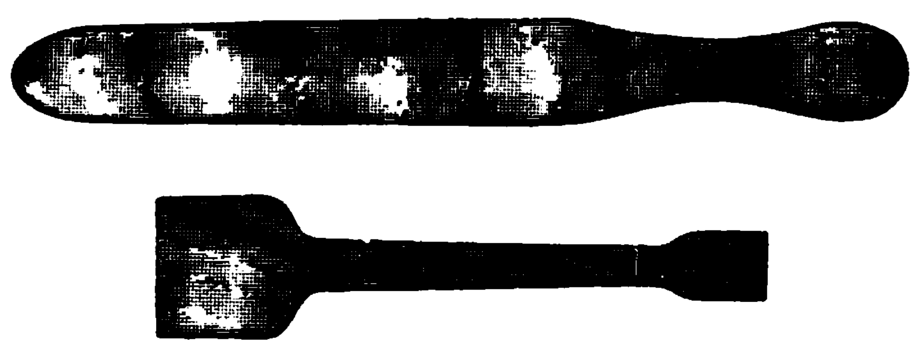


Ointment Spatula.

FIG. 198.

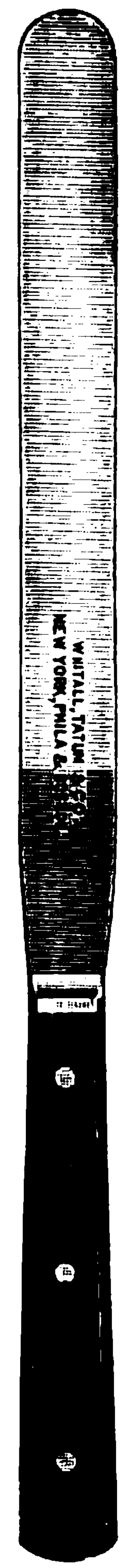
Pill Spatula.

FIG. 199.



Horn Spatulas.

FIG. 200.



Powder Spatula.

entirely of metal (nickel plated). The so-called Lawrence spatula is the best among these; the handle not being polished affords a good grip. The only objection to these, is that after being some time in use the plating is liable to wear off from the tip, exposing the surface of the steel beneath.

Spatulas are employed in the process of trituration, for the removal of the particles of powder adhering to the sides of the mortar and pestle, also in all the various phases of dispensing pharmacy, such as the division of powders, preparation of ointments, etc. Steel spatulas are adapted for general use except for such purposes where the substance is affected by contact with iron, as in the preparation of ointments containing iodine, salicylic and tannic acids, mercuric chloride, and corrosive substances. In such cases we employ the horn or hard rubber spatula, the latter being of flexible steel covered with hard rubber. Horn and rubber spatulas should not be used for stirring hot liquids.

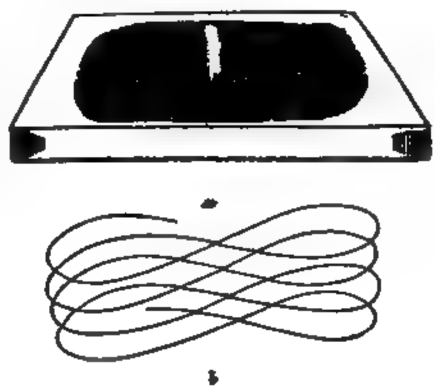
Too much care cannot be paid to the cleansing and care of spatulas; they should always be bright and free from traces of

rust, as its presence may render preparations unfit for use.

LEVIGATION.

Levigation consists in reducing substances to very fine particles by triturating them in the presence of some fluid in which they are not soluble. This is accomplished by means of the slab and muller, or a pestle and mortar. The substance, in coarse powder, is placed on a slab of glass, marble or porphyry, having a ground surface, and moistened with water or alcohol to form a thick paste; it is then triturated by means of the muller, using slight pressure, and moving the muller in curves such as shown in Fig. 201, *a*, *b*. A shallow porcelain mortar (Fig. 202) is often substituted for the slab, and a flat-surfaced pestle for the muller. In European pharmacy this latter operation is designated as Levigation, and the former as Porphyrization. These processes have for their object the reduction of such substances as zinc oxide, or mercuric oxide, to a very fine state of subdivision, which is not attainable by the simple process of dry trituration.

FIG. 201.



Porphyry Slab and Muller.

FIG. 202.

Levigating Mortar.

ELUTRIATION

Is the process of separating the finer particles of an insoluble powder from the coarser, by means of suspension in water and subsequent decantation. The pasty mass resulting from the process of levigation, is washed off into a beaker or other suitable vessel, and stirred with water; the mixture is then allowed to stand a minute or so, after which the supernatant turbid fluid containing the lighter suspended particles, is poured off into another beaker. The sediment which contains the coarser particles, is then again subjected to the process of levigation, and the same operation is repeated until the whole quantity is elutriated. The turbid fluid, which has been decanted, is allowed to stand at rest until the minute particles of the substance held in suspension have subsided; this deposit is then collected and

FIG. 203.

Elutriation.

dried. Instead of pouring off (decanting) the turbid fluid as described above, we may employ a more expeditious method, illustrated in Fig. 203, in which, by means of a long funnel tube, water is forced in at the bottom of the cylinder, which, forcing its way upward through the powder, carries the particles of powder along with it, the finer particles being carried to the top, while the coarser remain near the bottom, from their own gravity. By opening different outlets on the sides powders of various degrees of fineness may be obtained. The process of elutriation is employed in separating the impurities from chalk in the manufacture of prepared chalk, also in the preparation of the various lake colors, also in the sorting of emery into different grades of fineness.

TROCHISCATION

Consists in forming conical masses of levigated substances. Insoluble powders, such as chalk, bismuth salts, or bole, while still in a pasty condition, are placed into a tin cone (*d*, Fig. 204). This is then grasped by the handle (*c*), and the leg of the frame is tapped gently upon a slab of chalk-stone, or other absorbing surface, each tap causing a conical drop to fall out. The porous block absorbs the moisture quickly, after which the cones may be dried by heat, if necessary.

FIG. 204.

Mould for Levigated Chalk, Etc.

CHAPTER X.

SOLUTION.

Solution is a "molecular" subdivision of a body (solid, liquid or gas), in a liquid (*solvent*), the result being a clear homogeneous fluid.

If, on bringing a solid in contact with a liquid, the whole or a portion of the solid disappears, and a clear liquid results or can be separated from the mixture, then we say that the solid is wholly or partially soluble in the liquid.

Formerly, the solution of a solid in a liquid, such as that of salt in water, was designated as "simple" or "direct" solution, and where a change in the chemical nature took place, as when bases were dissolved in acids, as "indirect" or "chemical" solution.

Such a distinction is not necessary, and moreover incorrect, for we must consider, that "solution" in such a case is only apparent, there being new bodies of a different chemical constitution produced, which, as such, are dissolved in the excess of the solvent. The chemical action which takes place *first*, has nothing to do with the phenomena of solution.

The rate or ratio, according to which a substance is dissolved by any particular liquid, is called its "*solubility*." The solvent powers of a liquid for different bodies are very different. If none of the substance is taken up by the solvent, it is said to be "*insoluble;*" if comparatively little is dissolved, it is designated as "*difficulty*" or "*slightly soluble*" (example, calcium hydrate); when large amounts are taken up readily, as "*very soluble*" (example, potassium iodide).

When a solvent has taken up as much of the substance as it is capable of at a certain temperature, it is said to be "*saturated*." If there be an insufficient amount of the body present, it will be entirely dissolved and an "*unsaturated*" solution will result.

The solubility of a solid depends upon several conditions:

1st. The Nature of the Substance (form, density).

2d. The Nature of the Solvent.

3d. Temperature.

4th. Presence of other dissolved Solids.

The Nature of the Substance must be considered. The solubility of a solid depends primarily upon its nature, for we find, for instance, that barium sulphate requires 250,000 parts of water for solution,* while on the other hand, sodium thiosulphate is soluble in all proportions in water (at 45° C.).

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* Silver bromide at 20° C., is soluble 1 in 1,971,650 parts of water.

The Nature of the Solvent plays a very important part in solution. We find the solvent powers of water entirely different from those of alcohol, ether or glycerin.

The chief solvents employed in pharmacy are water, alcohol, glycerin, ether, chloroform, acids and oils.

Water is a general solvent of wide application. It is employed in the preparation of the medicated waters, syrups, solutions (liquores), etc. When it is used in the preparation of silver solutions, eye-washes, hypodermic solutions, etc., it should be distilled and fulfill all the requirements of the Pharmacopœia. Water dissolves most inorganic salts; from vegetable drugs it dissolves gums, starch, sugar, neutral principles, certain alkaloids, tannins, extractive and many coloring matters.

Alcohol is of the greatest importance pharmaceutically, because of its excellent solvent properties and the stability of the preparations made with it. It is a solvent for resins, volatile oils, alkaloids, and neutral principles, while it does not take up such inert principles as starch, albumen and gum, which cause the rapid deterioration of aqueous solutions.

Glycerin.—The solvent properties of this lie between that of alcohol and water, and when added to either of these, it insures greater stability of the finished preparation. It dissolves tannin, starch, many inorganic salts, pepsin, organic acids, etc. (See Glycerites.)

Ether dissolves principally fixed and volatile oils, fats, resins, and most alkaloids (not their salts).

Chloroform possesses about the same solvent properties as ether, but it has the advantage that it is not inflammable.

Acids.—Acetic acid in a diluted form, is employed as a solvent in the preparation of the official vinegars. Glacial acetic acid and hydrochloric acid are solvents of many organic compounds.

Oils are employed as solvents of gums and resins in the preparation of liniments.

Effect of Temperature on Solubility.—Rise of temperature usually increases the solubility of a solid. In some cases, we find that the solubility increases in a definite ratio with the temperature of the solvent, for example, potassium chloride, barium chloride, or magnesium sulphate. In another class (the majority), we find the ratio of solubility to the temperature irregular. In a small number of cases we find that the solubility steadily diminishes as the temperature rises, that is, the substance is more soluble in cold, than in hot water. As examples of this we have calcium hydrate, sodium chloride, strontium sulphate, calcium citrate, and paraldehyde.

The relationship of temperature to solubility is most clearly shown by the table of curves, Fig. 205, where the lower line of figures express the degree of temperature, and the side figures the quantity dissolved by 100 parts of the solvent.

In cooling a hot saturated solution, a portion of the dissolved body separates out in a solid (usually crystalline) form, while the remainder, according to its *coefficient of solubility for the given temperature, remains in solution. When bodies of different degrees of solubility are dissolved, the less soluble separate out first, while the more soluble remain in solution.**

The Presence of Dissolved Bodies in a solution often affects the solubility of other substances in this menstruum. Here we may distinguish several different cases:—

1st. The presence of one salt may *increase* the solubility of another. For instance, the presence of an alkaline chloride, such as sodium or ammonium chloride, increases the solubility of mercuric chloride in water. Iodine is practically insoluble in water, but by the use of an alkali iodide, we can cause water to take up large amounts of it (example, Lugol's Solution). This is an example where it is possible for us to form a saturated solution (KI), which is capable of taking up a further quantity of a second substance (I).

FIG. 205.

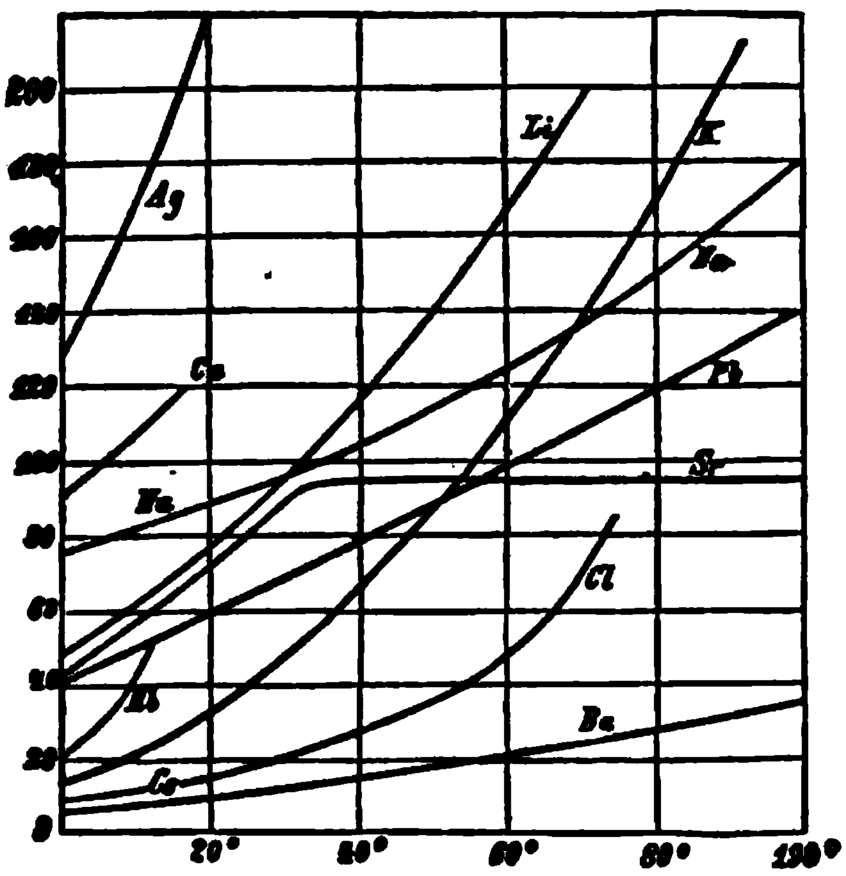

Table of Curves of Solubility for Nitrates. (Ostwald.)

2d. The presence of one salt may *diminish* the solubility of another. For example, we cannot dissolve potassium sulphate in a solution of ammonium sulphate, or potassium nitrate in a solution of ammonium nitrate. Potassium carbonate is a very soluble salt, but it is insoluble in concentrated water of ammonia.

3d. An alteration in the nature of the solvent may alter the solubility of the salt. The addition of alcohol to many saline solutions will cause the salt to be precipitated. For example, on adding alcohol to a saturated solution of ferrous sulphate, the iron salt will be precipitated as a granular powder.

CONDITION OF CONTACT OF THE BODY WITH THE SOLVENT.—We may facilitate the solution of solids by triturating or agitating them in *powder* form with the solvent; this facilitates the contact of the two, by continually exposing the surfaces of the particles of the powder to the contact of fresh portions of the solvent. This same principle is involved, when air or carbonic acid gas is passed rapidly through a mixture of the solid and fluid, for the purpose of producing brisk agitation.

CIRCULATORY SOLUTION.—When the quantity of matter to be dissolved is large, and the time permits, we may suspend the

---

* Coefficient is a number, expressing a certain arithmetical ratio. "Coefficient of solubility" is the number expressing either how many parts of a salt, etc., are soluble in 100 parts of a solvent, or how many parts of a solvent are required to dissolve 1 part of a salt.

substance, placed in a porous diaphragm (perforated funnel, sieve or muslin bag), just below the surface of the liquid solvent. A more or less saturated solution (resulting from the immediate contact of the solvent with particles of the solid), owing to its density, sinks to the bottom of the vessel, and its place is taken by fresh portions of the solvent displaced. This circulation continues until the liquid becomes saturated. This same procedure applied to the extraction of soluble matter from vegetable drugs

FIG. 206.

Apparatus for Generation, Washing, and Solution of Gases.

is known as "Circulatory Displacement," and is employed in the preparation of infusions, tinctures (by maceration), etc.

SUPERSATURATED SOLUTIONS.—A hot saturated solution of Glauber's salt ($Na_2SO_4 + 10H_2O$), when proper care is taken to protect it from jarring and dust, may be cooled, and still remain liquid, notwithstanding the solution contains a larger amount of the salt than the coefficient of solubility for the lower temperature allows. The slightest jar, or bringing it in contact with a solid body, causes its solidification at once. Such a solution is called "*supersaturated.*"

SOLUTION OF GASES.—Gases are usually more soluble in alcohol

than in water. The most easily condensible gases are the most soluble. The method of solution is the reverse of that usually employed in dissolving solids, that is, the solvent is kept as cool as possible. Under like conditions of pressure and temperature, one and the same liquid does not absorb equal quantities of different gases. At a temperature of 0° C., and a pressure of 760 Mm., one volume of water dissolves the following volumes of gas:—

Carbonic acid (carbon dioxide, CO_2),	1.8
Sulphuretted hydrogen (H_2S),	4.3
Sulphurous acid (sulphurous anhydride, SO_2),	79.8
Hydrochloric acid (HCl),	503.0
Ammonia (NH_3),	1050.0

Solutions of such gases as chlorine, sulphuretted hydrogen, sulphurous acid or ammonia, are often prepared by the apothecary. For the preparation of such solutions, the apparatus as shown in Fig. 206 may be employed. The gas is generated in the flask *a*, which is provided with a safety tube *c*; the gas passes out through *d* into the wash-bottle *f*, which contains a little water, for the purpose of retaining impurities; then it passes on through the tube *i* into the water contained in flask *g*. The tube dips just a little below the surface of the water which half fills the bottle, which is placed in a bath, *h*, of cold water. The neck of the bottle is loosely plugged with cotton to prevent the escape of gas. At short intervals the bottle is removed, its mouth closed with the ball of the thumb, or palm of the hand, and agitated until the unabsorbed gas is dissolved. This procedure is continued until, after shaking, pressure on the hand is observed from escaping gas. A better method for the preparation of chlorine water is that of Liebig (Fig. 207), in which the current of gas (as soon as the air is removed from the apparatus), is passed into an inverted retort filled with water. As soon as some gas has collected over the surface of the water, it is shaken until dissolved; this is continued until the water is saturated. This avoids the escape of odors into the room. The operation of shaking the excess of gas with the water or solvent, is not necessary in the case of such soluble gases as ammonia and sulphurous acid. In preparing solutions of these in water, care should be taken to keep up a steady current of gas, and when the operation is over, the receiver should be at once disconnected at the rubber joint *e*, before the lamp is removed from under the sand-bath *b*, because the vacuum created by the cessation of hot vapors would cause the contents

FIG. 207.

Preparation of Chlorine Water.

of the wash bottle (*f*) and receiver (*g*), to be separated back into the flask.

DENSITY OF SOLUTIONS.—On bringing a salt or gas into solution in a solvent, the specific gravity (density) of the liquid is generally increased. In most instances, this increase is in definite ratio to the amount of the body dissolved. The specific gravity of water being 1.000, if we dissolve five parts by weight of caustic soda in it, we will find the specific gravity to have risen to 1.059; if ten parts, to 1.115, etc. If we dissolve 31.9 parts of hydrochloric acid in water, the specific gravity will be 1.163. On the other hand, if we make a solution of ten per cent. of ammonia gas in water, we will find the specific gravity to be 0.960; and if one of 28 per cent., 0.901. The specific gravity of a solution, is a ready and fairly accurate means of determining the amount of dissolved salt or gas, when only one substance is present.

CHANGE IN VOLUME BY SOLUTION.—Most salts, when dissolving in water cause contraction; where water of crystallization is taken up by the salt, the contraction is greater than in the case of salts having combined water. On diluting a concentrated solution, contraction takes place. Expansion of volume takes place when the dissolved solid contains a large amount of water of crystallization, or a decided rise of temperature takes place. For example, when we dissolve ferri sulphas exsiccatus or alumen exsiccatum in a measured volume of water, we find that a contraction of volume results, since these salts have withdrawn respectively 7 or 24 molecules of water; on the other hand, if we dissolve the crystalline salts, we find an increase in volume, due to the throwing off of 7 or 24 molecules of water. On mixing absolute alcohol and water, a contraction of from three to four per cent. takes place, according to the proportions of the two; it being greatest when 49.836 volumes of water are mixed with 53.939 volumes of absolute alcohol; at 15° C. the mixture measures exactly 100 volumes, instead of 103.775.

FREEZING MIXTURES.—The passage of bodies from the solid to the liquid state (or, of the solid or liquid to the gaseous), produces a consumption of energy, which is accompanied by a lowering of the temperature; hence in dissolving salts, particularly those which dissolve rapidly, a cold mixture results.*

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*FREEZING MIXTURES.

If the liquids employed be first cooled, a greater diminution of temperature will take place.

On Mixing:—	*The Temperature is Lowered,* *From*	*To*
1 pt. each of Ammonium Nitrate and Water,	+ 10°	— 15° C.
8 pts. powd. Glauber's Salt and 5 pts. Hydrochloric Acid,	+ 10°	— 17° C.
2 pts. Snow and 1 pt. Salt,	0°	— 21° C.
1 pt. each of Ammonium Chloride, Potassium Nitrate and Water,	+ 10°	— 25° C.
9 pts. Sodium Phosphate and 4 pts. Dil. Nitric Acid,	+ 10°	— 29° C.
1 pt. Snow and 1 pt. Dil. Sulphuric Acid,	— 7°	— 50° C.
7 pts. Snow and 10 pts. cryst. Calcium Chloride,	0°	— 55° C.
A mixture of Ether and solidified Carbon Dioxide,	..	— 110° C.
Pictet's Fluid (liquefied mixture of SO_2 and CO_2),	..	— 200° C.

ELEVATION OF TEMPERATURE DUE TO CHEMICAL ACTION.—In the process of solution, we find many instances where a considerable amount of heat is generated, as when dissolving anhydrous caustic soda or potash or calcium chloride in water. From these solutions we can obtain the crystalline salts $NaOH + 7H_2O$; $KOH + 2H_2O$; $CaCl_2 + 6H_2O$. The enormous rise of temperature produced by the addition of sulphuric acid to water is also attributable to the fact, that *chemical action* has taken place, with the *absorption of water of hydration.* The mixing of 30 parts by weight of absolute alcohol with 70 parts of water causes a rise of temperature of 9.14 degrees, producing probably the hydrate $C_2H_5OH.3H_2O$.

DETERMINATION OF THE SOLUBILITY OF SUBSTANCES.

In order to ascertain the solubility of a body, we have recourse to either one of two methods:

1st. *Method of Digestion.*—When we expose an excess of the powdered substance to the action of the solvent, during a period of from several hours to a day, at the desired temperature. We place the mixture of the two in a small flask or test-tube, which is placed in a bath kept at the desired temperature, and shaken at frequent intervals. After digestion has been continued sufficiently long, the entire mass (liquid and undissolved powder), is quickly drained on a small *dry* filter. The filtrate is collected in a tared beaker and weighed, then evaporated to dryness, cooled in a desiccator, and again weighed.

2d. *The Method of Cooling.*—We heat the mixture of the solvent and substance, until a concentrated solution has been obtained at a temperature *higher* than that at which the determination is to be made. This solution is then cooled to the desired temperature, and maintained at this point for some time, under addition of some crystals of the salt, and agitation. It is then filtered and treated as directed above.

In applying either of the above methods to the determination of the solubility of a solid, in a *volatile* menstruum, it is best to employ a small flask with an inverted condenser (Fig. 151) to avoid loss of solvent. Then a sufficient quantity is filtered quickly into a stoppered weighing flask (Fig. 208), this is closed, allowed to cool and weighed. The volatile liquid is then evaporated off, and the weight of the dry residue determined. Care must be taken, that the proper temperature (at which the solubility is to be determined) is maintained for at least an hour before filtration.

FIG. 208.

Weighing Bottle.

In carrying out the above, for crystalline salts, the evaporated solution must be dried at a temperature sufficiently high to drive off all water of crystallization, and the residue then weighed as anhydrous salt, but calculated back to crystalline when the results are estimated.

Example: A saturated solution of potassium chlorate at 12° C., weighed 10.98 Gm.; when evaporated to dryness it gave 0.7025 Gm. residue. What was the amount dissolved? Let the weight of the saturated solution be taken as W, and the weight of the substance found therein dissolved, be w; then W — w will equal the weight of the water; we make the proportion (W — w) : w : : 100 : x or $x = \frac{100\,w}{W-w}$ Substituting figures (W = 10.98; w = 0.7025) we have: W — w = 10.2775 the weight of water in the solution.

Then

$$\overset{\text{Weight of water,}}{10.2775} : \overset{\text{Dry residue,}}{0.7025} :: 100 : X$$
$$X = 6.83$$

That is 100 parts of water had dissolved 6.83 parts of potassium chlorate at 12° C.

For convenience, solubilities are sometimes expressed by stating the amount of solvent required to dissolve one part of the solid. Then in this case it would be—

as

$$\overset{\text{Dry residue,}}{6.83} : \overset{\text{Weight of solvent,}}{100} :: 1 : X$$
$$X = 14.64.$$

That is, 14.64 parts of water held 1 part of potassium chlorate in solution at 12° C.

AN APPARATUS ("LYSIMETER") FOR DETERMINING SOLUBILITIES.

In determining the solubility of a substance in some liquid at a given temperature, there is usually but little difficulty encountered, when the solvent is not very volatile and the temperature at which the determination is to be made is not high. With a highly volatile solvent, and a high temperature, however, certain difficulties present themselves which are liable to lead to error. The main difficulty is encountered in the endeavor to separate from the original solution, which usually contains an excess of the substance in suspension, a *filtered* portion at the same temperature as that of the solution. The higher this temperature is, the more difficult becomes the removal of a portion without the introduction of errors by the ordinary methods of filtration. It appears, therefore, that it is only necessary to modify the method of filtration in such a way as to maintain the temperature of the original solution unchanged in order to eliminate these errors. This may be easily accomplished by upward filtration into a tube placed in the original solution, and so constructed that it will enable the operator to control the act of filtration, as well as accurately to determine the amount of solvent and dissolved material. For this purpose the little apparatus here described has been found very serviceable.

The apparatus consists of a glass tube, *a*, 15 centimeters long, and one centimeter in external diameter, provided at one end with a well-ground stopper, *c*, while the other end is cup-shaped, there being a contracted neck between the cup and the main tube. Into this cup is made to fit a carefully ground glass bell, *e*, having a small perforation in its bottom (as shown in *f*). There is also a stopper, *b*, which is carefully ground to fit into the cup, and which is inserted after the glass bell, *e*, has been removed. The several stoppers, etc., are all numbered, to show where they belong.

FIG. 209.

The Lysimeter.*

To show how the apparatus is used, it will be best to quote a practical example.

Let us assume that the solubility of morphine in boiling alcohol is to be determined. It will be necessary to provide for such an amount of liquid that at least one-half of the glass tube, *a*, may be immersed in the liquid. In the case of comparatively cheap solvents and substances to be dissolved, beaker glasses may be used; for more expensive materials test-tubes of such a size that there will be no great waste of material are preferable.

The glass tube is made ready by inserting the stopper, *c*, and introducing into the cup-shaped end the glass bell, *e*, containing a pellet of purified cotton and prevented from dropping out by a thin platinum wire fastened around the contracted neck and crossed over the mouth of the bell. A sufficient amount of alcohol having been introduced into a beaker or test-tube, heat is applied and morphine added, until, after the boiling has been kept up some time, a portion of the alkaloid remains undissolved. The prepared glass tube is now inserted in the liquid. As long as the stopper, *c*, closes the mouth of the tube, no liquid will be able to filter upwards. When the tube has acquired the temperature of the boiling liquid the stopper, *c*, is removed, whereupon the liquid will begin to filter through the pellet of cotton and rise in the tube as far as the quantity of liquid will permit. In order to insure perfect uniformity of the liquid within and without the tube, it is best to allow the filtered portion to flow back through

* This apparatus was devised by Dr. Charles Rice of New York City. The description as given was published in the *Journal of Amer. Chem. Society*, Oct., 1894.

the pellet of cotton once or several times. The stopper, *c*, having then been inserted, the tube is withdrawn, turned upside down, the glass ball removed, and the stopper, *d*, inserted. The tube is now carefully cleaned with alcohol, and laid aside until cold. Its tare having previously been determined, the increase in weight represents the weight of the solution contained therein. On transferring or washing the contents into a tared beaker or capsule, and evaporating, the weight of the dissolved morphine will be found.

PERCENTAGE SOLUTIONS.

It must be distinctly understood, that percentage by weight means that *all* ingredients must be *weighed*, and percentage by volume, that *all* ingredients must be *measured*. A 1 per cent. solution of cocaine hydrochlorate contains 1 part by weight of the salt, and 99 parts by weight of water; a 2 per cent. solution contains 2 parts by weight of salt, and 98 parts by weight of water. The word *part* may stand for a grain, or gramme, or ounce, or *any* unit. To make a fluidounce of a 1 per cent. solution we first need to know the weight of a fluidounce of water, at the temperature at which we desire to make our solution. We find that a fluidounce (of 480 minims) of water at 15.5° C. weighs 455.7 grains, hence 1 per cent. of this would be 4.55 + grains. Subtracting this from 455.7, we obtain 451.2 + grains. Consequently, we dissolve 4.5 grains of cocaine hydrochlorate, in 451.2 grains of water at this temperature. If we desire to make one fluidounce of an alcoholic solution of cocaine hydrochlorate, we must first find the weight of 1 fluidounce of alcohol. If we use U. S. P. alcohol of specific gravity 0.820, then 455.7 times 0.820 gives us 373.6 +, the weight of 1 fluidounce of this alcohol, in grains; then we proceed as above. To prepare a pint of a 1 in 1000 solution of cocaine hydrochlorate, divide 7,291 (grains in 1 pint of water) by 1000; this gives the number of grains (7.29) of the salt per pint, and sufficient water must be added to make the product weigh 7,291 grains. In these calculations, 1 grain of the salt was assumed to occupy the same space as 1 minim of water, which is not exactly the case,* hence a solution prepared as above, will measure two or three minims less than a fluidounce. For all practical purposes however, this is near enough, but when an exact volume (say exactly 1 fluidounce) is desired, it is best to make a quantity, a little in excess, and then to throw away what is not needed or to dispose of it otherwise. Many physicians in prescribing solutions understand percentage by measure, *i. e.*, grains of a solid to the fluidrachm or fluidounce, or milligrammes to the cubic centimeter; this is *weight* for *measure* and not percentage. For convenience

* *Jour. Chem. Soc.*, 1892, page 766.

in dispensing, the table of Puckner or that of Loudenbeck are useful.* See tables of E. Wright, in Appendix.

RULES AND EXAMPLES FOR DILUTION AND FORTIFICATION.

In applying these rules, percentage by volume or weight may be used; the two must not be confounded or mixed in carrying out the calculations. Alcohol is selected as illustration; but in place of this, such liquids as ammonia water, hydrochloric or acetic acid, or any others may be selected. For further study of this subject the reader is referred to Oldberg's "Pharmaceutical Problems and Exercises," from which these examples are selected.

RULE I.—To find the quantity of water required to be added to alcohol of any given percentage strength, to dilute it to any other percentage strength desired:—*Divide the per cent. strength of the alcohol to be diluted* (*a*) *by the percentage desired* (*b*), *and subtract* 1 *from the quotient; the remainder is the number of parts of water* (*x*) *to be added to each part of the alcohol used to produce the result desired.*

$$\frac{a}{b} - 1 = x.$$

Example.—We have a 90 per cent. alcohol to be diluted to 60 per cent.:—

$$\frac{90}{60} = 1.50\text{; and } 1.50 - 1 = 0.50.$$

Therefore: ½ pound of water is to be added to 1 pound of the 90 per cent. alcohol to reduce it to 60 per cent.

RULE II.—To make a definite quantity, by weight, of alcohol of any given percentage strength from any stronger alcohol:—*Multiply the required quantity* (*a*) *by the desired per cent.* (*b*) *and divide by the per cent. strength of the stronger alcohol used* (*c*)*; the quotient is the weight of stronger alcohol required* (*d*) *to be diluted with water; and the difference between that weight* (*d*) *and the weight of the diluted alcohol desired* (*a*), *is the weight of water* (*e*) *necessary for the dilution.*

$$\frac{a \times b}{c} = d\text{; and } a - d = e.$$

---

* Using pure water at 22° C. (71.6° F.), 1 fluidounce weighing 455.19 grains.

To make:	For each fluidounce of water take of the salt— Grains:	To make:	For each fluidounce of water take of the salt— Grains:
1 per cent.,	4.597	1 in 1000,	0.456
2 per cent.,	9.289	1 in 500,	0.912
3 per cent.,	14.078	1 in 400,	1.141
4 per cent.,	18.966	1 in 300,	1.522
5 per cent.,	23.957	1 in 200,	2.290
10 per cent.,	50.576	1 in 100,	4.597
15 per cent.,	80.327	1 in 50,	9.289
20 per cent.,	113.797	1 in 25,	18.966
25 per cent.,	151.730	1 in 20,	50.576
40 per cent.,	303.460	1 in 5,	113.797

—*The Apothecary*, Feb. 1892, 10–13.

Example.—6 pounds of 60 per cent. alcohol is to be made from an alcohol of 90 per cent. strength:—

$$\frac{6 \times 60}{90} = 4 \text{ ; and } 6 - 4 = 2.$$

U.S.P. Rules for making an Alcohol of any required lower Percentage, from an Alcohol of any given higher Percentage.

I. By Volume.—Designate the volume-percentage of the stronger alcohol by V, and that of the weaker alcohol by v.

Rule.—Mix v volumes of the stronger alcohol with pure water to make V volumes of product. Allow the mixture to stand until full contraction has taken place, and until it has cooled, then make up any deficiency in the V volumes by adding more water.

Example.—An alcohol of 30 per cent. by volume is to be made from an alcohol of 94 per cent. by volume.—Take 30 volumes of the 94 per cent. alcohol and add enough pure water to produce 94 volumes.

II. By Weight.—Designate the weight-percentage of the stronger alcohol by W, and that of the weaker by w.

Rule.—Mix w parts of weight of the stronger alcohol with pure water to make W parts by weight of product.

Example.—An alcohol of 50 per cent. by weight is to be made from an alcohol of 91 per cent. by weight.—Take 50 parts by weight of the 91 per cent. alcohol, and add enough pure water to produce 91 parts by weight.

ALLIGATION.

Rule I.—To find the value of any mixture of known quantities of ingredients, each of known value:—*Multiply the quantity of each ingredient by its value and add the several products; divide the sum by the sum of the quantities of the several ingredients; the quotient is the value of the whole mixture.*

Example.—We mix 3 pounds of 80 per cent. alcohol, 8 pounds of 91 per cent. alcohol, 5 pounds of 45.5 per cent. alcohol, 6 pounds of 40 per cent. alcohol, and 8 pounds of water; what will be the alcoholic percentage strength of the mixture?

$$\begin{array}{rcl} 3 \times 80 & = & 240. \\ 8 \times 91 & = & 728. \\ 5 \times 45.5 & = & 227.5 \\ 6 \times 40 & = & 240. \\ \underline{8} \times 0 & = & \underline{0.} \\ 30 & & 1435.5 \end{array}$$

$$\text{and } \frac{1435.5}{30} = 47.85 \text{ per cent.}$$

Rule II.—To find the proportional quantities of ingredients of known value required to produce a given mean value:—*Write the numbers expressing the units of value of the respective ingredients*

in a column to the right, and the mean sought, to the left; link together the numbers expressing the respective values of any two ingredients, one of which is above and the other below the mean value sought; take the difference between the mean and the value of each ingredient, and place that difference opposite the value of the other ingredient to which it is linked; the differences are the proportions required of the ingredients opposite whose values they are placed. Thus:—

Example.—Five substances of different value are to be mixed so as to yield a product of the mean value of 14. The value of the several substances are: 9, 12, 13, 16, and 18. How much of each substance will have to be taken?

$$
\begin{array}{c|c|lrl}
 & 9 & 2 & & = 18 \\
 & 12 & 4 & & = 48 \\
14 & 13 & 2 & & = 26 \\
 & 16 & 1+5 & & = 96 \\
 & 18 & 2 & & = 36 \\
\hline
 & & 11+5 = 16 &) & 224 \; (\; 14 \\
 & & & & 16 \\
 & & & & 64 \\
 & & & & 64
\end{array}
$$

The first ingredient, having a value of 9 (which is a value below 14), is linked to the fourth ingredient, having the value of 16 (which is above 14). The second ingredient, with the value of 12, is linked to the fifth, with the value of 18; and the third ingredient, having a value of 13, is linked to the fourth in the same manner. As the difference between 13 and 14 is 1, we place the number 1 opposite 16, to which the 13 is linked; and as the difference between 14 and 16 is 2, we place the number 2 opposite the 13 to which the 16 is linked. Then taking another pair, we put the number 4 opposite 12, because 12 is linked to 18, and the difference between 14 and 18 is 4; and opposite 18, which is linked to the 12, we put the number 2, which is the difference between 14 and 12. One more pair now remains, viz.: that of 9 and 16. Opposite 9 we put the number 2, because 2 is the difference between 14 and 16, to which 9 is linked; and opposite 16 we put the number 5 (in addition to the number 1 already placed opposite 16), because 5 is the difference between 14 and 9. Now we add together the numbers set opposite the ingredients, which are 11 + 5, making the total 16 parts. In other words, we must use 2 parts of the ingredient represented by 9; 4 parts of the ingredient having the value of 12; 2 parts of the third ingredient; 1 + 5, or 6 parts of the fourth ingredient, and 2 parts of the fifth, making 16 parts in all, and we will find that this mixture will have a mean value of 14.

CHAPTER XI.

DIFFUSION—DIALYSIS.

Diffusion is the mutual permeating of two or more liquids or gases, or an intermixture of the molecules of liquids of different density; it is of the same nature as solution. As to their diffusive powers through water, liquids differ widely; fixed oils do not, volatile oils slightly, while syrups, glycerin, alcohol, crystalline salts, etc., readily diffuse in every proportion. If water is poured carefully upon a layer of sulphuric acid, the two form distinct layers, but, on standing they gradually intermix, that is, they *diffuse* into one another. The same may be said of saline solutions and various other liquids. They all differ from one another, however, in the rapidity with which they diffuse; solutions of such substances as starch, dextrin, gum, albumen, glue, etc., diffuse exceedingly slowly, if at all. Graham, considering gelatin as a type of this latter class, has proposed to call them *colloids* (*κόλλη*, glue), to distinguish them from the far more easily diffusible *crystalloid* substances.

Graham proposed a method of separating bodies based on their unequal diffusibility, which he called *dialysis*.

Dialysis is the diffusion between liquids modified by the interposition of an animal or vegetable membrane. It is the process of separation of crystalline from non-crystalline or colloidal substances by the interposition of a membrane. This membrane, whether of bladder or parchment-paper, possesses an infinite number of minute pores (capillary tubes), by means of which the liquids are brought in contact with each other and "diffuse." This is called osmosis. A *dialyser* consists of a ring of hard rubber or other suitable material, over one end of which was stretched, while wet, a sheet of parchment paper or a piece of bladder, thus forming a vessel about two inches deep and about ten inches in diameter. Into this vessel is poured the mixed solution to be dialysed, and the whole floated in another vessel containing water (Fig. 210). Glass vessels may be used in making the dialyser, as shown in Fig. 211, but because of its weight, the dialyser should be supported to the proper depth in the water. The mixture in the dialyser should not be over one-half of an inch deep on the diaphragm. A bladder filled to about two-thirds with the mixture and suspended in a jar of distilled water, answers just as well. If the mixture placed in the dialyser (floating vessel), consists of crystalloid and colloid matter, it will be found, after a period of from several hours to a day or so, that only the colloids remain in the dialyser, while the crystalloids have diffused through the membrane into the distilled water of the outer vessel. This solution is called the *diffusate*.

The process of dialysis is employed by the chemist as well as the pharmacist. The toxicologist separates such poisons as arsenic, antimony, lead, alkaloids, etc., from the contents of a stomach, by placing the material in the dialyser, which is suspended in acidulated distilled water; these poisons, being crystalloids, readily

FIG. 210.

Dialyser.

diffuse through the membrane and are identified in the diffusate. The pharmacist may purify salicylic acid by a process of dialysis, or may separate many crystalline organic bodies from their impurities. We can remove in this manner the crystalline active constituents from the preparations of such drugs as opium, aconite, belladonna, etc. B. F. McIntyre of New York introduced a class of preparations called Dialysates, based on this idea, whereby the active constituents were removed from the inert matter in the various drugs.

FIG. 211.

Dialyser.

Thus far we have learned that the diffusate contains the material we seek, while that left on the dialyser is discarded. In the case of *Dialysed Iron*, however, it is just the reverse, the colloid matter left on the dialyser being the material aimed at, while the crystalloids (ammonium chloride and ferric chloride) with any free acid pass into the diffusate, and are thrown away.

CHAPTER XII.

CRYSTALLIZATION.

Generally speaking, bodies, in passing from the liquid or vaporous condition to the solid state, assume regular geometric forms. Such regular forms, bounded by plane faces and definite angles, are called crystals. The phenomenon of formation is called *crystallizing*. We define bodies which are capable of assuming this form, as *crystallizable* (as quartz, alum, etc.), and those which have assumed it, as *crystalline*. Such bodies as do not conform to the above, that is, do not crystallize, are called *amorphous* (as chalk, glue, etc.). When a body is freshly broken, we often observe the fractured surfaces to exhibit a crystalline structure. This is sometimes called "*crystalline fracture*" (as marble, alabaster, etc.). The plane surfaces which bound a crystal are called *faces* or *planes*.

The intersection of two adjacent faces (planes) forms an *edge*. When two or more lines or planes intersect, their edges form an *angle*. In order to classify and compare the various forms of crystals, we must have some simple method of expressing the relative position and inclination of their planes. This is done by referring them to certain systems of axes. These axes (Figs. 212, 218, 222, etc.), are called crystallographic axes; they are imaginary lines, which, if drawn through, would intersect at the centre of the crystal. The position of the different faces (planes) of the crystal are fixed by, and expressed in, the relative lengths of their intercepts on these axes. For the purpose of comparing the different crystal planes, systems of symbols have been devised, which aim to locate the position of each plane, with reference to its relation to the crystallographic axes.*

Since every crystalline body has its own peculiar crystal form, it will be readily seen that we have an immense number of these in all possible varieties. However, in the face of this, according to their greater or less degree of symmetry, they are divided into six different classes or systems.

Each one of these systems has its imaginary crystallographic axis to which the different planes (faces) bear a fixed symmetrical position. According to the relative position, number and size of these different planes, we distinguish the following six different systems.

1. Regular system.
2. Tetragonal system.
3. Hexagonal system.

---

* For different systems see Williams' "Elements of Crystallography."

4. Rhombic system.
5. Monoclinic system.
6. Triclinic system.

1st. The *Regular* (monometric, isometric, tesseral) System. All forms have *three* axes of *equal* length, which intersect at angles of 90° (Fig. 212).

The fundamental form of this system, from which all others are most easily derived, is the regular octahedron (or octohedron) (Fig. 213), with eight equilateral faces (crystal form of the alums). If the six octahedral angles be truncated, we have the crystal form of potassium chloride (Fig. 214). Imagine square truncations on the octahedral angles; then we have the six sided hexahedron (cube), the crystal form of potassium iodide and sodium chloride (Fig. 215). By the truncation of the twelve octahedral angles, we obtain, according to the size of the new faces, the form (Fig. 216), and the rhombic dodecahedron (Fig. 217), the crystal form of phosphorus, boracite, etc. In a similar manner, the various other forms of this system are obtained.

2d. The *Tetragonal* (dimetric, quadratic, pyramidal) System has *three* axes, which

Fig. 212.

Fig. 213.

Fig. 214.

Fig. 215.

Fig. 216.

Fig. 217.

Regular or Isometric System.

intersect at angles of 90°, *two* of these (lateral) being of *equal* length, the other (principal axis), being either longer or shorter. The fundamental form of this system is the tetragonal pyramid (Figs. 219, 221). By truncating the horizontal angles, we obtain the square pyramid (Figs. 223, 224), the crystal form of tin-stone. By the truncation of the upper and lower angles of the tetragonal pyramid, we obtain the crystal form of potassium ferrocyanide (Fig. 220).

3d. The *Hexagonal* (rhombohedric) System has *four* axes. The number of *equal* axes (lateral) are *three*, intersecting the principal axis at angles of 90°, and each other, at angles of 60°. The fourth or principal axis is of greater or lesser length (Fig. 222). The fundamental form, is the double hexagonal pyramid (Fig. 225), bounded by twelve similar scalene triangles, *from* which, the forms of the hexagonal prism, closed by the basal pinacoid (Fig. 227), or by a pyramid (Fig. 226), are derived. In this system we find quartz, iceland spar, arsenic, bismuth, antimony, sodium nitrate, camphor, ammonium chloride, thymol, etc.

4th. The *Rhombic* (orthorhombic, prismatic, trimetric) System has *three* axes of *unequal* length, all intersecting at right angles (Fig. 228). The fundamental form is the rhombic octahedron (Fig. 229), bounded by eight congruent scalene triangles.

To this series belong sulphur, saltpeter, magnesia, zinc sulphate, tartar-emetic, citric acid, etc.

FIG. 218.

FIG. 221.

FIG. 223.

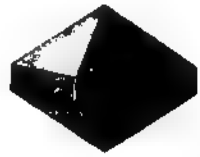


FIG. 224.

FIG. 219.

FIG. 222.

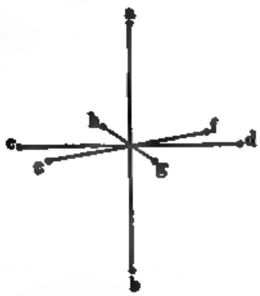


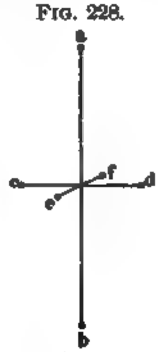
FIG. 225.

FIG. 220.

Tetragonal and Hexagonal Systems.

5th. The *Monoclinic* (oblique, monosymmetric, prismatic) System has *three* axes of *unequal* length, two of which intersect at an oblique angle, being perpendicular to

FIG. 226. FIG. 227. FIG. 228. FIG. 229.

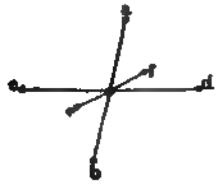


Rhombic or Ortho-rhombic System.

the third (Fig. 230). The fundamental form of this is the monoclinic octahedron (Fig. 231), bounded by eight scalene triangles of two different forms; one set of

which has a degree of inclination toward the axes different from that of the other. The most frequent and characteristic form of this system is the monoclinic prism

FIG. 230. FIG. 231. FIG. 232.



Monoclinic System.

(Fig. 232). To this system belong sulphur (fused), sodium sulphate, ferrous sulphate, cane sugar, oxalic acid, tartaric acid, etc.

FIG. 233. FIG. 234.

Triclinic System.

6th. The *Triclinic* (asymmetric) System has *three* axes of unequal length, all oblique to one another (Fig. 233). The most common form is the triclinic octahedron, all of the upper or lower faces of which have a different degree of inclination toward the three axes. To this system belong copper sulphate, potassium bichromate, etc.

When a body crystallizes in two or more forms, belonging to *different* systems, it is said to be *polymorphous.* When of *two* forms it is called *dimorphous,* as for example; sulphur crystallizes in the rhombic and monoclinic systems. When the body crystallizes in *three* forms, belonging to different systems, it is said to be *trimorphous,* for example, titanic acid is found in three forms, as rutile, brookite and anatas.

Different bodies having the same crystal form are designated as *isomorphous.* Chemically analogous compounds, which have the same crystal form, have the power of crystallizing in variable proportion with one another, also to exchange their constituents. In the case of ordinary alum

$$(Al_2(SO_4)_3 + K_2SO_4 + 24H_2O)$$

the bases may be replaced by

$$Fe, -Cr, -Mn, -\text{or } Na, -NH_4, -Rb, -Cs,$$

respectively, without a change in their crystal form. A crystal of ordinary alum, when suspended in a solution of chrome-alum, grows as though it were in its own solution. This is explained by the similar atomic and molecular structure of the isomorphous bodies.

The terms *prismatic* and *acicular* are often applied to long pointed crystals, and *tabular* to those crystallizing in flat plates. Although not used in crystallography, these three terms are very common and convenient, since they describe the general outward appearance of the crystal, without complicating matters with

technical terms. The determination of the crystalline form, that is of the system and stereometric form, to which a crystal may belong, is often a very difficult matter, involving a knowledge of cleavage, the use of the polarizer, refractometer, goniometer, etc.; hence the reader is referred to the various text-books on Mineralogy and Crystallography.*

The different conditions under which crystallization takes place are the following:—

1st. Crystallization through the cooling of vapors; that is sublimation, which happens only in the case of volatile solids, such as calomel, benzoic acid, iodine, corrosive sublimate, etc.

2d. Crystallization through the cooling of fused masses. Examples are sulphur, antimony or bismuth; the beautiful crystalline sulphides of nature, as those of iron, antimony, etc.

3d. Crystallization through deposition from solutions.

This may take place under either of the two following conditions: *a*, By the spontaneous evaporation of concentrated solutions at a uniform temperature. *b*, By the slow cooling of a hot supersaturated solution.

4th. By precipitation, as the result of chemical interaction or alteration of menstruum.

1st. *Crystallization through Sublimation* (see Sublimation).

2d. *Crystallization through Fusion and Partial Cooling.*—To obtain these substances in a crystalline form, they should be fused in a deep vessel (Hessian crucible), and when sufficiently cooled, the crust which forms over the surface is pierced and the melted material drained off; on examining the interior, the sides will be found covered with crystals.

3d. *Crystallization through Deposition from Solutions.*—The object of crystallization is that of purification, for when we obtain a body in well-defined crystals, this is a proof that it is practically pure. This method of purification is now sometimes applied to the purification of such liquids as chloroform, acetic ether, glycerin, phenol, etc.; these, on being exposed to an extremely low temperature, crystallize, thus enabling us to separate the non-crystallizable impurities (Pictet's patent).

(*a*) In order to carry on crystallization successfully, we must observe certain precautions: *First,* that the solution be perfectly clear and free from mechanical impurities. *Second,* that it be brought to the proper degree of concentration, for upon this depends the size and character of the crystals. In order to obtain large and well-defined crystals, it is best to subject the solution to slow "spontaneous evaporation." This is employed particularly in cases where the salt is very soluble, as in potassium bromide and iodide; here the solution, after being brought to the proper degree of concentration, is set aside in a dry place of uniform temperature.

* Williams' "Elements of Crystallography," Tschermack's, also Dana's "Mineralogy," etc.

Should variations of temperature take place, a portion of the salt, having crystallized out at a lower, would be again dissolved at a higher temperature.

The proper degree of concentration, requires a consideration of the nature and solubility of the substance. If it is very soluble, a boiling saturated solution should not be made, otherwise we would obtain a granular mass. The proper degree of concentration is always determined beforehand by experiment on smaller quantities. When the body is not very soluble, the solution is evaporated until a *pellicle* or crust forms over the surface, and then set aside. Manufacturers are guided by the density and quantity of the solution, in conjunction with the temperature of the air. It must not be forgotten that the quantity of the solution determines largely the size of the crystals.

(*b*) *The method of crystallizing by slowly cooling hot supersaturated solutions*, is employed largely in the crystallization of organic bodies. In dissolving these, we employ besides water, such solvents as alcohol, ether, chloroform, benzol, benzin, petroleum, hydrochloric and acetic acids. Each solvent has its own peculiarities and applications. When we employ this method, we dissolve the body in the hot solvent, so as to produce as concentrated a solution as possible. This is best accomplished by adding the solvent by degrees to the dry substance, until just enough has been added to dissolve it at a boiling temperature. The solution is then set aside and allowed to cool slowly so that crystals may deposit. The slower the rate of cooling, the larger and better defined are the crystals. For this reason, we often allow the vessel to cool in a bath of hot water.

The evaporation of saline solutions is carried on in shallow vessels. Volatile solutions are placed in deep vessels; these are then set aside in a warm place and left undisturbed. The *slightest jarring* hinders the formation of large crystals. For this reason, the hot saturated solution of Epsom salt is stirred while cooling. This prevents the formation of large rhombic prisms, and produces in their stead, small needles.

Sometimes these saturated solutions refuse to crystallize. This is overcome by the introduction of rough or angular bodies, or by rubbing the sides of the vessel with the stirring rod, or by introducing a few crystals of the substance which is in solution. Strings or thin sticks of wood are often placed in the crystallizing vats, which, by their rough surfaces, offer points of adhesion, attracting the nuclei and facilitating the deposition of crystals around them; this accounts for the long cylindrical masses, in which we receive milk sugar, rock candy, tartar emetic, prussiate of potash, copper sulphate, etc.

The liquid remaining after crystallization is called the "*mother liquor*." This, on further concentration, yields another crop of crystals called the "second crystallization," which are, however,

not as pure as the first. Thus, cane-sugar crystallizes from its first solution in pure white crystals; the mother liquor on further concentration yields a second crop of a yellowish cast; still further, we obtain crystals of a brown color. That this brown color is simply due to mechanical impurities, is shown by the fact that, by repeated crystallizations (*recrystallization*), the body can be obtained of a pure white color.

If more than one body be present in a solution, and their solubilities differ, they may be readily separated; for the least soluble crystallizes out first, and so on in the order of their solubility, the most soluble last. This method of separation is called "*fractional crystallization.*"

Some substances are insoluble in the usual solvents; hence saline solutions must be employed. Thus, mercuric iodide may be obtained in beautiful prisms by crystallizing it from a solution of common salt; this is called "*intermediate crystallization.*"

FIG. 235. FIG. 236.

Growing Crystals.

Every crystal has a hypothetical center point; around this, the formation takes place with development of the different faces and planes. It is rare to find all the faces of a crystal fully developed. Crystals with deficient faces may be developed by "*growing*," that is, by suspending them by a thread in a concentrated solution of the salt, or laying them on the bottom of the vessel, with the deficient face up (Figs. 235, 236).

Certain substances do not crystallize, but when concentrated and spread out on glass in thin layers they dry, forming thin transparent *scales*. These are often mistaken for crystals. As examples of these scale compounds we have pepsin, citrate or tartrate of iron, etc.

4th. *Formation of Crystals by Precipitation or Chemical Interaction.*—This can scarcely be considered, from the standpoint of inorganic chemistry, as a method of crystallization, inasmuch as the product obtained is thrown out of solution by mechanical or chemical means, usually yielding precipitates of a granular nature (see Precipitation, Granulation). In crystallizing many organic

compounds, it is necessary to alter the menstruum after solution has been effected. For instance, let us assume that we have an organic body which is extremely soluble in alcohol, and only partly soluble or insoluble in ether. Now in order to facilitate crystallization, we may add a little ether to the alcoholic solution, thus producing a sufficient alteration in the solvent power of the menstruum, to facilitate the formation and deposition of crystals.

Crystallization, as the result of chemical interaction, is often brought about by bringing together solutions of different substances. For example, on bringing together two inorganic bodies, we have the following:—

$$\underset{\text{Ammonium Chloride.}}{2NH_4Cl} + \underset{\text{Platinic Chloride.}}{PtCl_4} = \underset{\text{Ammonium Platino-Chloride.}}{(NH_4)_2PtCl_6}$$

On bringing together an organic and inorganic body we have the following:—

$$\underset{\text{Allyl Iodide.}}{C_3H_5I} + \underset{\text{Potassium Sulphocyanate.}}{KSCN} = \underset{\text{Allyl-Sulphocyanate (Oil of Mustard).}}{CSN — — C_3H_5} + \underset{\text{Potassium Iodide.}}{KI}$$

When it is desired to crystallize small amounts of substances, from an aqueous solution, it is best to place the crystallizing

FIG. 237.

Draining Crystals.

FIG. 238.

Crystallizing Vessel.

vessel in a desiccator, which facilitates the spontaneous evaporation of the solvent.

After crystallization has taken place, the vessel is inclined, to facilitate the draining off of the mother liquor (Fig. 237). After this, the crystals are thrown into a funnel (stopped with cotton or glass wool) and the remaining mother liquor allowed to drain off. This draining may sometimes be facilitated by pouring over the mass some liquid in which the crystals are not soluble. We occasionally use alcohol for this purpose, in the case of certain inorganic salts. The crystals are finally dried by laying them between the folds of filter paper or on porous tiling.

When the crystals are small, forming a granular mass, they are best freed from mother liquor by throwing the entire mass on a perforated porcelain plate, in a funnel, and draining off by suction (see page 182). Large quantities of crystals are drained by placing

them in the centrifugal machine (see page 214). Since no pressure is here employed, the structure of the finest crystalline mass is not injured.

Effect Of The Solvent On Crystallization.

Here we must distinguish between several cases:

1st. *The solvent takes no part, either physically or chemically, in the crystallization.* Thus ammonium chloride, potassium iodide, and potassium sulphate crystallize from their aqueous solutions free from water of crystallization.

2d. *The solvent takes part in the formation of the crystals, in furnishing crystal water.* Thus in the formation of ferrous or cupric sulphate, or of sodium carbonate, water of crystallization is withdrawn from the water present. We have examples of such salts which crystallize with different proportions of water. Sodium carbonate is capable of crystallizing with one, five, eight or ten molecules of water. Glauber's salt crystallizes with ten molecules of water of crystallization from a cold solution, and from hot water with seven molecules, or in an anhydrous condition, according to the temperature. Again, such organic substances as alkaloids and glucosides, may crystallize out from different solvents, in crystals of different form, each form being characteristic of the solvent.

Such salts give up their water of crystallization readily; and many, such as sodium carbonate, ferrous sulphate, etc., give up a portion of their water on exposure to the air (see Efflorescence).

3d. *The solvent plays a chemical and physical part in the crystallization.* When water enters into the chemical constitution of the crystal, it is called "*water of constitution*," while, when it merely serves for the formation of the crystal it is called "*water of crystallization.*" The water of constitution is not lost by mere efflorescence, but only after subjecting the salt to prolonged high temperature.

In many crystals, particularly those of the tesseral system, water is mechanically enclosed during the formation of the crystal, and is called "*interstitial water.*" Such crystals, on heating, *decrepitate,* from the explosive force of the minute water sacs, as they rupture the crystal. As examples of these we have potassium chlorate and nitrate.

CHAPTER XIII.

GRANULATION.

Granulation is disturbed crystallization. We resort to this process to obtain many salts in a convenient form (coarse-grained powder) for dispensing. It also often adds to their general elegant appearance. For many salts this is a process of purification. The solutions of very soluble salts, such as potassium carbonate, citrate, or bromide, or sodium salicylate, are rapidly concentrated, and then slowly evaporated to dryness on a water bath with constant stirring, which causes the salt to separate in a granular form. Ammonium chloride is thus granulated, having first undergone purification by the addition of water of ammonia to its boiling solution, and subsequent filtration. When evaporating a solution to dryness for the purpose of obtaining a granular salt, care must be taken, that the powder does not cake on the bottom of the dish. Potassium chlorate and ferrous sulphate are granulated by constantly stirring their supersaturated solutions, while rapidly cooling. The former is soluble in 1.7 parts, and the latter in 0.3 parts of boiling water, while in cold water, the former is soluble in 16.7 parts while the latter is soluble in 1.8 parts. Ferrous sulphate, because of its greater solubility in cold water, is more conveniently granulated by filtering its concentrated solution into alcohol, in which it is insoluble. These granulated or granular salts should be thoroughly dried before being introduced in bottles.

GRANULAR EFFERVESCENT SALTS.

The terms *granular* and *granular effervescent* salts should not be confused, for aside from the term, they present nothing in common. The object of the granular effervescent salt is to afford a convenient and pleasant method of administering many medicinal substances, by combining them with a mixture containing an organic acid and sodium bicarbonate, and forming into coarse granules, so that when it is thrown into water effervescence ensues.

These are prepared by thoroughly mixing dry medicated powders with dry and powdered citric or tartaric acid and sodium bicarbonate, then moistening the mixture with alcohol (or any menstruum which is not a solvent of the constituents), to form an adherent porous mass. This is then forced through a sieve and the granules dried quickly in a current of dry hot air, or placed in a hot drying closet. It may then be sorted into different sized granules by sifting. These products should be kept in hermetically sealed bottles.

The U. S. Pharmacopœia recognizes three granular effervescent salts, viz: Caffeina citrata effervescens, lithii citras effervescens, and magnesii citras effervescens.

CHAPTER XIV.

EXSICCATION.

Exsiccation consists in depriving crystalline salts of their water of crystallization. Such salts as contain a large amount of crystal water, as potassium alum (45.5 + per cent.), sodium carbonate (62.9 per cent.) and ferrous sulphate (45.3 + per cent.) are exsiccated for the purpose of reducing their bulk, thereby increasing their comparative strength. This is particularly evident in preparing pills which may contain any of the above, for, by using the dried salts we reduce the difficulty of making, as well as the size of the pills. In preparing these exsiccated salts, we should first allow them to effloresce in a warm place, after which they are subjected to a strong heat under constant stirring (they melt in their own crystal water), until free from water; when cold, the mass is powdered and placed in dry bottles. These anhydrous salts, when dissolved in water, may be made, by evaporating their solutions, to assume their original crystalline condition.

The U. S. Pharmacopœia recognizes three exsiccated salts, viz:—Alumen exsiccatum, sodii carbonas exsiccatus, and ferri sulphas exsiccatus. For the purposes of illustration the method of preparation of the latter is given.

"FERRI SULPHAS EXSICCATUS, *Dried Ferrous Sulphate*. Approximately $2FeSO_4 + 3H_2O = 357.28$.

"**Ferrous Sulphate, in coarse powder, one hundred grammes, 100 Gm.**

"Allow the salt to effloresce at a temperature of about 40° C. (104° F.), and then heat it in a porcelain dish, on a water-bath, with stirring, until the product weighs from *sixty-four* (64) to *sixty-five* (65) *grammes*. Lastly, reduce the residue to a fine powder, and transfer it at once to perfectly dry, well-stoppered bottles."

This process removes six out of the seven molecules of water of crystallization. Too high a temperature (not exceeding 149° C.), should not be employed, otherwise the salt undergoes decomposition, turning a brown color, instead of yielding a grayish-white powder as it should.

CHAPTER XV.

DELIQUESCENCE AND EFFLORESCENCE.

Deliquescence is the property, possessed by many salts, of absorbing moisture from the air. Such substances should be kept in well closed bottles in a dry place. Efflorescence is the property possessed by many salts when they are exposed to the air, of gradually giving up their water of crystallization and becoming dry and powdery on the surface.

DELIQUESCENT SALTS OR SUBSTANCES.

Acidum Chromicum.
Ammonii Iodidum.
" Nitras.
" Valerianas.
Aurii et Sodii Chloridum.
Caffeina Citrata.
Calcii Bromidum.
" Chloridum.
Chloral.
Ferri Chloridum.
" et Quininæ Citras.
Hyoscyaminæ Hydrobromas.
" Sulphas.
Lithii Bromidum.
" Citras.
" Salicylas.
Magnesii Citras Granulatus.
Pepsinum.
Pilocarpinæ Hydrochloras.
Physostigminæ Sulphas.
Potassa.
" cum Calce.
Potassii Acetas.
" Carbonas.
" Citras.
" Cyanidum.
" Hypophosphis.
" Sulphis.
Soda.
Sodii Hypophosphis.
" Iodidum.
" Nitris.
Sparteinæ Sulphas.
Strontii Bromidum.
" Iodidum.
Zinci Bromidum.
" Chloridum.
" Iodidum.
All granular effervescent salts.

EFFLORESCENT SALTS.

Acidum Citricum.
Cadmii Sulphas.
Codeina.
Cupri Acetas.
" Sulphas.
Ferri et Ammonii Sulphas.
Ferri Sulphas.
Magnesii Sulphas.
Plumbi Acetas.
Potassii Ferrocyanidum.
Quinine Salts.
Sodii Arsenas.
" Acetas.
" Benzoas.
" Boras
" Hyposulphis.
" Carbonas.
" Phosphas
" Sulphas.
Strychnine Salts.
Zinci Acetas.
" Sulphas.

EFFECTS OF THE EXPOSURE OF CHEMICALS TO LIGHT AND AIR.

Acidum Hydrocyanicum undergoes decomposition, depositing a black precipitate which may be prevented by the addition of a little hydrochloric acid.

Acidum Nitrohydrochloricum decomposes, losing chlornitrous acid; it should be kept only in small quantity, in partly filled bottles in a dark place.

Acidum Sulphuricum rapidly absorbs moisture.

Acidum Sulphurosum oxidizes to sulphuric acid.

Ammonii Carbonas loses NH_3 and CO_2, and becomes bicarbonate.

Apomorphinæ Hydrochloras turns green, indicating partial decomposition.

Aqua Chlori decomposes with formation of hydrochloric acid and oxygen.

Calx Chlorata loses chlorine, absorbing CO_2.

Calx Sulphurata loses sulphuretted hydrogen, changing to sulphate.

Chloral as well as Camphor are slowly volatilized.

Iodides or bromides of arsenic, ammonium, iron, mercury (ous and ic), sodium, strontium, sulphur, and zinc, lose iodine or bromine, respectively.

Magnesia (calcined) absorbs CO_2 and becomes carbonate.

Magnesii Sulphis oxidizes to sulphate.

Morphinæ Acetas loses acetic acid.

Napthalinum slowly volatilizes.

Oleatum Hydrargyri, U. S. P., deposits metallic mercury.

Physostigmine salts turn red.

Potassa Sulphurata forms carbonate, hyposulphite, and sulphate.

Resorcin becomes colored.

Silver salts are all decomposed by light in presence of organic matter.

Sodii Bisulphis loses sulphurous acid.

Santoninum turns yellow on exposure to light.

Zinci Acetas loses water and acetic acid.

Zinci Phosphidum oxidizes, losing phosphorus.

CHAPTER XVI.

PRECIPITATION.

Precipitation is a process, by which one or more substances which have previously been in a state of solution, are caused to separate out in an insoluble form. The substance which separates out is called the "*precipitate*;" the clear liquid above, the "*supernatant*" liquid; the substance added, the "*precipitant*;" and the process, "*precipitation*."

Most precipitates fall to the bottom of the vessel, because they have a higher specific gravity than the remaining liquid. Those which are light, rise (for instance, Pepsin), and some may remain suspended throughout the liquid for a long time.

The various causes which bring about precipitation, are:—

1st. *Change of Temperature.*—By boiling a solution of albumen or lime water, we cause precipitation (see pages 129, 184). If we cool a hot saturated solution of potassium chlorate, a precipitation or separation of a portion of the salt takes place. Changes of temperature often cause precipitation to take place in Fluid Extracts (see page 269).

2d. *Change in Menstruum.*—Any substance in solution is precipitated on the addition of a miscible fluid in which it may be insoluble. Such inorganic salts as ferrous and cupric sulphate are precipitated from their aqueous solutions on the addition of alcohol. Alcoholic solutions of resinous substances, on addition of water, separate their resin. Ether precipitates sugar from alcoholic solution. Chlorides of sodium and barium are precipitated from their concentrated aqueous solutions, upon the addition of concentrated hydrochloric acid.

3d. *Chemical Interchange.*—When the precipitant added produces a chemical change among the substances in solution, the result depends on the insolubility of a new compound formed, as when sulphuric acid is added to a solution of barium chloride, which causes the production of insoluble barium sulphate. The addition of soluble potassium iodide to a solution of lead acetate, produces insoluble lead iodide. If the solutions are cold, the precipitate is amorphous; if hot, crystalline.

This form of precipitation is applied in analytical operations, as well as in the manufacture of many chemicals.

4th. *Light.*—This causes precipitation in the solutions of many silver compounds in the presence of organic matter etc., also to some extent in some pharmaceutical preparations, as in some Fluid Extracts, etc.

Precipitation may have for its object:

1st. *To obtain the substance in as fine a powder as possible.* Examples: Precipitated chalk or magnesium carbonate.

2d. *To remove impurities.* Iron is removed from calcium chloride by precipitation with calcium hydrate; from zinc chloride solution by precipitation with zinc carbonate. An impure sodium acetate is freed from sulphuric acid by the careful addition of barium acetate, etc.

3d. *To obtain new chemical compounds;* for instance, lead iodide and mercuric iodide, ammoniated mercury, bismuth subcarbonate and subnitrate, etc.

4th. *The qualitative and quantitative determination of substances.* In analytical chemistry, we identify and separate the various groups by means of different precipitating reagents. We also ascertain the quantitative composition of different bodies, by the precipitation and subsequent weighing of the various constituents.

As to their appearance, precipitates are designated as:

Crystalline — produced, for instance, by the cooling of hot saturated solutions of salts.

Amorphous — produced, for instance, by precipitation of ferric chloride by alkalies.

Granular — produced, for instance, by addition of alcohol to a concentrated aqueous solution of ferrous sulphate.

Curdy — produced, for instance, by addition of hydrochloric acid to a solution of silver nitrate.

Flocculent — produced, for instance, by precipitation of albumen with alcohol.

Gelatinous — produced, for instance, by addition of collodion to carbolic acid.

Magma —is a pasty mass resulting from the straining or filtering of an amorphous precipitate retaining water mechanically. Examples, ferric hydrate, aluminum hydrate.

Hot, dense solutions, yield dense precipitates.

Cold, dilute solutions, yield light (diffusible) and often crystalline precipitates.

Dense precipitates are more easily washed, for they subside readily and admit of being washed by decantation.

Crystalline Precipitates.—In many operations, we aim to obtain the precipitated body in a so-called crystalline condition, for the purpose of facilitating its separation and subsequent purification.

For example, we cause calcium carbonate (precipitated chalk) and barium sulphate to be precipitated from hot solutions. This causes these compounds to form dense and crystalline precipitates, which are then easily removed and purified.

On mixing cold solutions, the precipitate formed will usually be crystalline and of greater purity; the solutions should be mixed slowly and with constant stirring. The precipitate will be denser, if it is allowed to stand at least twenty-four hours in the liquid. Example: On adding cold "magnesia mixture" to a cold, weak solution of a phosphate, a crystalline precipitate will gradually form, consisting of the double salt ammonium-magnesium phosphate. Light magnesia (MgO) is made from the *light* carbonate, which is made by reaction between *cold* solutions of sodium carbonate and magnesium sulphate. Heavy magnesia is made from the *heavy* carbonate, which is made by reaction between *hot* solutions of sodium carbonate and magnesium sulphate.

Amorphous Precipitates.—Amorphous precipitates (for instance, hydroxides or sulphides of the metals), are denser and separate more rapidly from saline solutions; for instance, when ammonium sulphydrate produces in solutions of ferrous salts only a green color of ferrous sulphide, the addition of ammonium chloride causes its immediate separation.

In order to obtain the hydroxides of aluminum ($Al_2(OH)_6$) and iron ($Fe_2(OH)_6$), the precipitation must take place in the cold, and in very dilute solutions, in order to insure a finely subdivided precipitate. Amorphous precipitates are much more easily washed in this finely subdivided condition. Moreover, in the case of the two examples quoted, precipitation must be effected in the cold, in order to obtain the precipitates in the *hydrated* condition and not as oxyhydrates (hot solutions). Upon these two conditions depends the solubility of ferric hydrate in solutions of the organic acids (preparation of scale salts).

In quantitative analysis many precipitates (metallic sulphides, hydroxides, etc.) are thrown down from boiling solutions, in order to render them as *dense* as possible. This will also cause them to settle rapidly, so that they may be washed by decantation; also this facilitates the solution of the soluble salt (impurity) formed by the reaction, which must afterward be removed by washing.

The *order* in which these solutions are added to one another, determines largely the purity of the product, and the ease with which it is afterwards washed. Hence, we should add the solution of ferric chloride to the diluted ammonia water, otherwise oxychlorides may be formed.

In preparing yellow oxide of mercury, we pour the solution of mercuric chloride into the solution of potassa, for if the operation is reversed we obtain red oxychloride of mercury.

In analytical operations we should add, for instance, the barium solution to the solution of the sulphate or sulphuric acid, otherwise some of the barium salt may be carried down with the precipitated barium sulphate.

The nature of the precipitate depends on the conditions under which the two solutions come in contact, that is, which of the two

remains longest in excess. If we pour a solution of mercuric chloride into a solution of potassium iodide, so that the latter remains in excess, the solution remains clear, because as long as the latter remains in excess the mercuric iodide is dissolved as fast as formed. If we reverse the order, having the mercuric chloride in excess, the mercuric iodide is likewise dissolved. It is only by a careful regulation of the proportions that success is obtained.

Fractional Precipitation has for its object the purification of substances by partial precipitation. For this purpose the precipitant is added only in small portions at a time, each precipitate being removed, before a further portion of the precipitant is added. In these different fractions, the substance may be found in different degrees of purity. Thus carbolic acid is separated from the empyreumatic resins which accompany it, by adding to its alkali solution an acid, in small portions at a time, the first precipi-

FIG. 239.

FIG. 240.

Precipitating Jar.

Beaker Glasses (nest).

tations consisting of these resinous impurities, while the later ones contain the acid in pure form. We may thus separate salicylic acid from its inert isomers by fractional precipitation with silver nitrate.

In carrying on precipitation, it is necessary that the liquid be constantly stirred during the addition of the precipitant; this is for the purpose of facilitating the contact of the substances dissolved in the liquids, also to prevent the precipitate from forming lumps, which might enclose particles of the substance yet unacted upon. With the exception of some operations in analytical chemistry, it is always advisable that both solutions be well diluted before mixing.

In direct precipitation, the precipitant is added until no further precipitation takes place. This may be ascertained by allowing

the precipitate to settle away from near the surface and then adding to the clear supernatant liquid a drop or two of the precipitant, which should not produce any further turbidity.

Precipitation is carried on, in small operations, in deep beaker glasses (Fig. 239), or in the so-called "*precipitating jar*" (Fig. 240), the latter being a deep, heavy glass vessel, broad at the bottom and narrow at the top. This enables the precipitate to settle over a larger area of surface, thus assisting the operations of washing and decantation. On the large scale earthenware jars are usually employed, in which the supernatant liquid may be drawn off by means of spigots placed at different heights; wooden tanks are also constructed upon the same principle.

CHAPTER XVII.

DECANTATION.

Decantation is the act of removing the supernatant liquid from a precipitate or sediment.* We usually resort to decantation in removing the clear supernatant liquid from a precipitate which may be deposited by tinctures or fluid extracts on standing. It is an expeditious and accurate method of separating soluble from insoluble matter, when conducted with due care. Decantation is employed in the process of Elutriation, where the lighter are separated from the heavier particles of matter, the former being suspended in the upper layers of the mixture.

By "decantation with washing," is understood the removal of soluble from insoluble matter in precipitates, by the repeated affusion and withdrawal of water. It is employed in those cases where a large quantity of a heavy, insoluble precipitate is to be washed, requiring, necessarily, a large amount of water. The precipitate is first allowed to settle; the supernatant liquid, after it has become clear, is drawn off; then hot or cold water is poured upon the precipitate, with thorough stirring. It is again allowed to settle and treated as before; this operation is continued, until all foreign soluble matter is removed.

FIG. 241.

Decantation with Guiding-rod.

In decanting off the supernatant fluid, it is necessary to use the guiding rod (Fig. 241), otherwise, owing to adhesion, the liquid will run down the side of the vessel (Fig. 242). If due care is taken, not a drop of the liquid need be lost. When the form of the vessel, or the quantity of the liquid, admits pouring

* A *Sediment* consists of solid matter, which is deposited by force of gravity, from solutions (in which it was suspended) on standing.

A *Precipitate* consists of solid matter (amorphous or crystalline), which separates from a solution, as the immediate result of a reaction, be it heat, light or chemical influence.

off without a guiding rod, the outside of the lip or edge of the vessel should be slightly greased; this prevents the adhesion of the liquid, and its running down outside. Decantation may be more expeditiously and thoroughly effected by means of the *siphon* (Figs. 244, 245). This is a glass tube, bent at an angle of about 60°, or bent at two right angles, having one of the limbs longer than the other. It is first started by filling it with fluid, while inverted like a Λ; then the longer extremity being tightly closed with the finger, the shorter end is immersed in the liquid, with the longer arm extending outside, below the level of the liquid. On removing the finger, the flow of liquid commences. By lowering the inner, shorter arm, the liquid may be almost entirely drained off. Fig. 246 illustrates a form well adapted to siphoning off volatile or caustic liquids; the siphon *a*, *b*, is fitted tightly through the cork *k*, through which also a mouth-piece, *c*, extends to just below

FIG. 242.

Careless Decantation.

FIG. 243.

Decanting over Greased Rim.

the cork. By blowing air in at *c*, the liquid is forced out through the siphon, which may be raised or lowered, according to the height of the precipitate. The same principle is applied in

FIG. 244. FIG. 245.

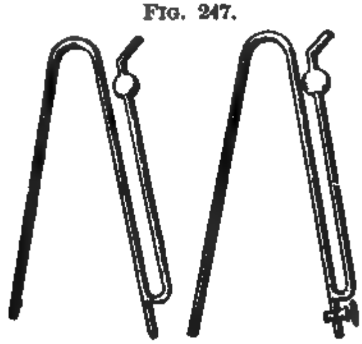
Decanting with Siphon.

drawing off acids, in which the air may be forced in, by means of a rubber bulb.

Fig. 247 illustrates another form of siphon which can be started by suction without danger or accident. The finger is

FIG. 246.

FIG. 247.



Siphon Apparatus.

Siphons with Suction Tubes.

placed over the end of the long limb, or the stop-cock temporarily turned off, and suction applied at the mouth-piece of the curved lateral tube, until the current is started.

In analytical operations, we usually wash precipitates first by decantation, pouring the decanted liquid through the plain filter, to avoid any possible loss of substance, then by means of the tip of a feather (Fig. 248), or a small glass rod tipped with a small piece of rubber-tubing, any particles of the precipitate that may be adhering to the sides of the beaker, are brushed down, and the entire mass carefully transferred to the filter, the beaker being several times rinsed with boiling (or cold) water, the feather or tipped rod being used to remove any adhering particles. The precipitate is further washed, dried or ignited, and then weighed.

FIG. 248.

Rinsing Out Precipitates.

FIG. 249.

Pipettes.

PIPETTES.—For removing small quantities of a supernatant liquid from precipitates, where the amount is not sufficient for siphoning, decantation is very difficult without entailing loss; hence we employ the pipette (Fig. 249). This consists of a long glass tube of small diameter, near the middle of which is usually blown a globular or elongated bulb, the lower tip being tapered out to a small opening. The tip of this is inserted into the liquid to be drawn off, and by suction, it is drawn up into the bulb; when filled, the upper end is quickly closed with the finger, or if a rubber tube be used (Fig. 297), closed by pinching.

Fig. 250, illustrates a suction arrangement which can be applied to any pipette; this consists of a glass tube (closed at one end), which fits closely, yet slides easily over the stem of the pipette; an air-tight joint is formed by a short piece of rubber tubing, which fits over the extremities of the outer tube and the stem of the pipette, then by raising or

lowering this outer tube, the liquid may be drawn up into, or discharged from the pipette.

Pipettes are also graduated for the purpose of draining off measured quantities of fluids.

Wash Bottle or Spritz Bottle.—In the various operations of rinsing and washing of precipitates, the "wash or spritz flask" is employed. This consists of a flat-bottomed flask (Fig. 251) fitted with a rubber stopper, having two holes, through which pass two glass tubes. The tube a, extending slightly below the cork, is the mouth-piece for forcing in the air, and this is tipped with a piece of rubber tubing. The tube b, d, is for the ejection of water. The tip b is drawn out to a point, to allow the passage of a fine stream of water; this tip is connected with the

Fig. 250.

Suction Arrangement for Pipettes.

Fig. 251.

Wash or Spritz Flask.

main tube c, by means of a short piece of rubber tubing at f, which arrangement enables the operator to direct the stream of water in any direction, without altering the position of the flask. Around the neck at e is wound heavy cord, to enable the operator to handle the flask when hot. If a continuous stream of water is desired, the flow is started by blowing through the mouth-piece; then the latter is quickly closed by forcing the thumb against the end of the tube a.

Automatic or Continuous Washing of Precipitates.—For this purpose there are a number of contrivances, answering also for the

continuous *filtration* of large quantities of liquids. Fig. 252 illustrates a convenient form in which the flask containing the wash-water is inverted over the funnel. Through the perforated cork of the flask extend two bent tubes (Fig. 253). The end *b* must reach higher than *c* or *d*; and *d* must extend farther than *c*. When placed over a funnel, the tip *a* should reach below the surface of liquid. As soon as the level falls below *a*, air enters at *b*, which admits a fresh supply of water until the end of the tube *a* is again immersed.

Another form is that devised by Gay-Lussac (Fig. 254). Instead

FIG. 252.

FIG. 254.

FIG. 253.

Automatic Filtering and Washing Apparatus.

of a bottle having two necks as illustrated, a single-necked bottle may be used as well. Through a tightly fitting cork two tubes are inserted, both of which are bent, forming two right angles as shown in the illustration, the inner (siphon) tube *b*, *a*, is bent so that one arm extends below the level of the bottom of the bottle, the tip being curved upward. The arm *d* extends down into the

funnel, being raised or lowered according to the height of liquid desired. The flow of liquid is started by blowing air in through *d*, the fluid flows through the siphon and as soon as it rises to the level where it closes the mouth of the outer tube *d*, *c*, the access of air is cut off, thereby stopping the further flow of liquid. As soon as sufficient of the liquid has run through the filter, air is again admitted into the tube *d*, *c*, which permits the siphon to flow filling up the funnel again.

FIG. 255.

Automatic Filtration of Volatile Liquids.

An arrangement as shown in Fig. 255 answers well for the filtration of, or washing with, volatile liquids. In this, the bottle, *A*, must be of such size as to fit well over the top of the funnel, the neck extending down some distance. The funnel, *T*, (with filter) is placed over the bottle, and then without separating the two, the funnel is placed into the neck of the receiving flask, *B*. The cord, *f*, serves to allow space for the escape of air.

CHAPTER XVIII.

COLATION.

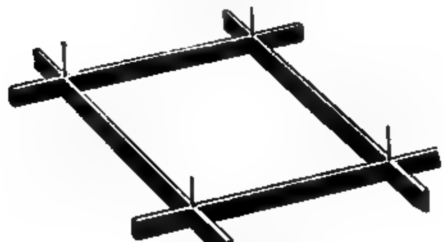
COLATION or straining is the process of rapidly separating precipitates and all kinds of suspended matter from fluids, by means of pouring them upon a cloth or other porous fabric. We employ this method, for the separation of mechanical impurities of all kinds, particularly in those cases where rapid filtration is required, and where the solid particles to be removed are not very finely divided, or the amount of precipitate is very large.

For this purpose we employ as filtering media, felt, flannel, cotton flannel, muslin, gauze, etc. The felt strainer being made of wool, is in the form of seamless conical bags; it forms an excellent strainer for oils, melted fats, honey, etc. Inasmuch as they are difficult to cleanse they should always be employed for straining the same material. In place of this, the woolen flannel strainer answers just as well; when over-seamed, they last a long time, and have the advantage that they are more easily cleansed; they are suspended from frames as shown in Fig. 256. While straining syrup or honey, the strainer should be hung in a warm place free from draughts. Canton or cotton flannel and muslin form the cheapest materials, and are most generally employed. Before

FIG. 256.

Straining Bag.

FIG. 257.



Strainer Frame.

using them, they should be well washed in boiling water, to remove any soluble matter that may have been used in calendering.

These strainers are then suspended from the corners of the strainer frame (Fig. 257) which may be supported by a clamp, or placed directly over a vessel. After most of the liquid has drained through, and if the amount of precipitate is large, the strainer should be removed from the frame by gathering it in along the sides, as shown in Fig. 258, and then the retained liquid should be forced out by a twisting motion. When the amount of sus-

Fig. 258. Fig. 259.

Forcible Straining.

pended matter is small, filtration through absorbent cotton answers all purposes. Each strainer or straining material should always be moistened before it is used. Should the fluid which first passes through not be perfectly clear, it should be returned to the strainer until the precipitate has filled the meshes of the cloth, when the liquid will flow through clear. If a clear liquid cannot be obtained in this manner, the strained liquid must subsequently be filtered through paper or other suitable medium.

For small operations at the dispensing counter, where it is necessary to remove suspended matter or precipitates from liquids, a small wad of absorbent cotton may be inserted in the neck of a

funnel and the fluid passed through. A very convenient "straining funnel," made of hard rubber, is shown in accompanying illustration; this is made in two parts, so that a paper or cloth strainer may be inserted in the body of the funnel.

CHAPTER XIX.

FILTRATION.

Filtration is the process of depriving liquids of solid or suspended matter, by passing them through some porous medium, which allows only the passage of the fluid; the clear, transparent liquid which flows through is called the "filtrate." For filtering purposes, we employ filter-paper, absorbent cotton, asbestos, spun and ground glass, charcoal, etc. When filtration is applied to viscous liquids, such as syrups, mucilage, honey, etc., for the purpose of removing mechanical impurities, it is called *straining*.

When we separate a heavy precipitate from a fluid, with which it is mixed, by draining through muslin, we call the process *colation*.

FILTER PAPER.—This consists of unsized paper of loose texture, which is to be had either in square or circular sheets. It is an essential requisite, from a pharamaceutical point of view, that the filter paper used should be prepared from clean materials.* For this reason as well as another presently to be mentioned, the *gray* filter paper, which is the cheapest in the market, should not be used for filtering pharmaceutical preparations. This sort of paper almost always contains iron, lead, lime, starch and coloring matter, the presence of which at once precludes its use for filtering solutions of sensitive chemicals, such as iodide of iron, hydriodic acid, iodine, etc. Aside from the color imparted by gray paper to preparations which are filtered when hot (for instance, magnesium citrate solution), they also acquire a disagreeable taste, due to the presence of organic impurities contained in the paper. For all purposes, the white paper of the various standard brands † (German, Swedish, French) should be used. A thick paper of compact texture will be found to give the best satisfaction in most cases. The different makers prepare a great variety of filter-papers adapted to all kinds of work. There is filter-paper of a dense close texture for removing fine suspended matter;

* According to Dr. Lardier, the *gray* filter paper usually employed, is made from cast-off rags of the filthiest sort, without any previous disinfection. It therefore contains enormous quantities of bacteria, which are apt to pass into the filtrate, and are capable of converting medicinal preparations into "culture fluids" for myriads of these organisms.

† The most suitable paper for general pharmaceutical purposes is Schleicher and Schüll's Nos. 595, 597 and 598. The 595 is a light, while the 597 and 598 are heavy papers; the first of these is best adapted for filtering tinctures, spirits, etc., while the latter two are more suitable for the rapid and clear filtration of denser fluids. For filtering syrups, fruit-juices, oils of all kinds, etc., a paper of thick, loose texture is necessary; this will be found in Nos. 584, 586 or 591; the larger sizes of these are sold with parchmentized points, so as not to break under the pressure of a heavy column of liquid. For quantitative purposes (*i. e.* quantitative analysis), Schleicher and Schüll's 589, and 590, or Munktell's No. 1 Swedish, or the Prat-Dumas French filter paper are the best. Messrs. Schleicher and Schüll prepare a hardened filter paper (No. 575) which possesses even in a damp state, a hardness and durability which almost equals parchment. This is specially adapted for pressure filtration, also for the collection or removal of moist precipitates.

paper of loose texture for the rapid filtration and removal of coarser particles; then paper of such a texture as to admit the easy filtration of syrups and oils. A very useful *toughened* filter paper is to be had in the market, which is made by drawing ordinary white filter paper through nitric acid (sp. gr. 1.42), and then immediately washing with water. The paper shrinks somewhat in this toughening process without impairing its filtering properties.

Another form of filter paper is that in which linen threads are interwoven throughout, thus strengthening the tissue and preventing its rupture, which often occurs with the ordinary filter paper, when the operator pours a quantity of liquid too suddenly into the filter.

For analytical purposes, it is necessary to select a paper that will not only retain the finest suspended matter, but which will also, when burned, yield the smallest possible amount of ash. In view of this, it is necessary that the paper be of a very close texture and yet not impede filtration; further, it is necessary that not more than traces of inorganic matter be present. These inorganic constituents (silica, alumina, oxides of iron and calcium) are always present in ordinary white filtering paper, but may be removed therefrom by washing with a diluted mixture of hydrochloric and hydrofluoric acids.

Plain and Folded Filters.—In pharmaceutical and chemical operations we employ both the "*plain*" and the "*folded*" filter. Each form has its specific uses.

The Plain Filter is employed in all operations where a precipitate is to be collected or subjected to washing. The filter is made by folding the square piece S (Fig. 260) along *a-b*, forming the triangle T (Fig. 261), which is again folded along the dotted line forming the triangle U (Fig. 262), this is rounded by cutting along *g–h* (in round filter paper not necessary), it is then laid open in conical form as shown in Fig. 263. A still better method is to fold the sheet along *a–b*, as shown in Fig. 265, then along *e–f* (Fig. 266), forming thereby a square, as shown in Fig. 267, this is then rounded by cutting, as shown in Fig. 262. Then by holding it in position with the finger, it is well moistened with water or alcohol, according to the nature of the liquid to be filtered, and by gently patting with the finger, the filter is made to fit the sides of the funnel closely. This precaution must be observed, particularly in analytical operations, to avoid the risk of washing particles of the precipitate down between the sides of the filter and funnel. In some operations, a double filter is employed, in which case two plain filters are taken, one being placed inside of the other, so that there will be four folds to each side.

For the economical use of expensive paper for analytical purposes, Edo Classen recommends cutting the filter in half and folding as illustrated in the diagram (Fig. 264). It is obvious that

this will answer for pharmaceutical work in all cases which allow or require the use of a plain filter.

When it is necessary to remove a precipitate from the filter after

FIG. 260.

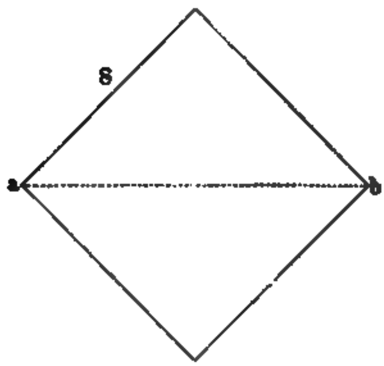


FIG. 261.

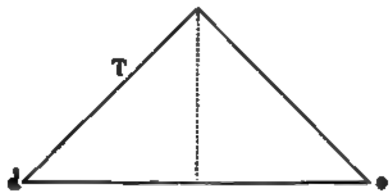
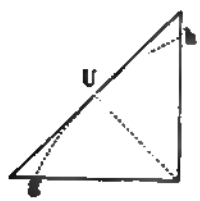


FIG. 263.

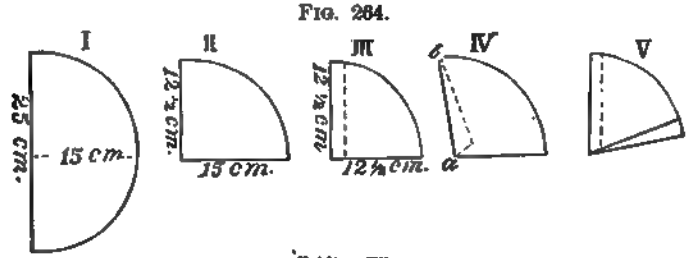
FIG. 262.



Folding Filters.

drying, as in opium assay, a special paper with a hardened smooth surface, which can be had in the market, may be used for this purpose.

FIG. 264.



Folding Filter.

The Plaited Filter.—For general pharmaceutical purposes, when the precipitate is not the desired object, for instance, in filtering tinctures, solutions, etc., the *plaited* filter is employed, because,

owing to its numerous folds, it increases the rapidity of filtration. The filter paper (round or square) is folded along the line *a–b* (Fig. 265), and then along *e–f* (Fig. 266), resulting in the square (Fig. 267); this is then folded along *c′–f*, forming a triangle (Fig. 268); this triangle is folded along the lines *g–f″*, forming an elongated short-based triangle (Fig. 269). This is opened to a

FIG. 265.

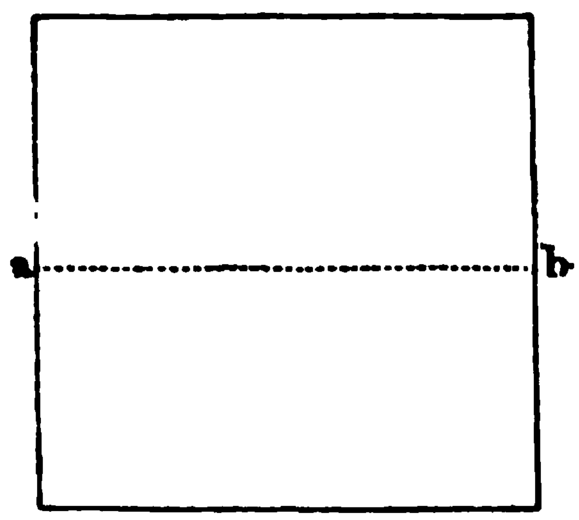


FIG. 266.

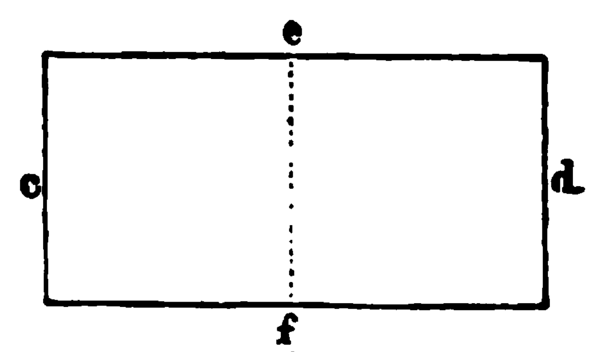


FIG. 267.

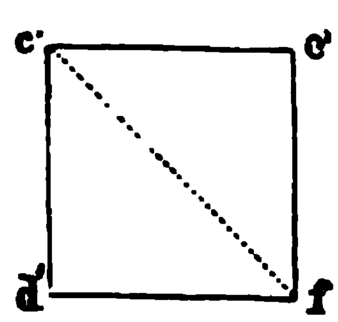


FIG. 268.

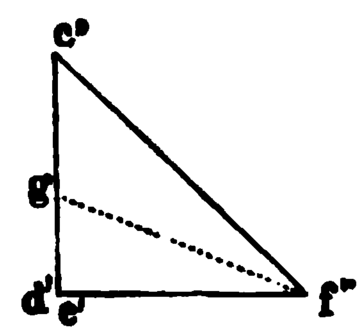


FIG. 269.

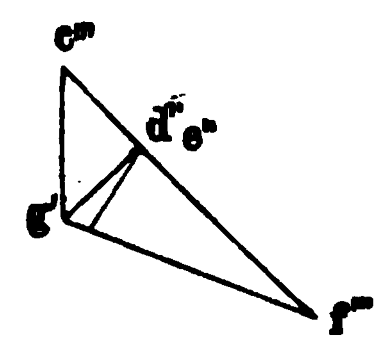


FIG. 271.

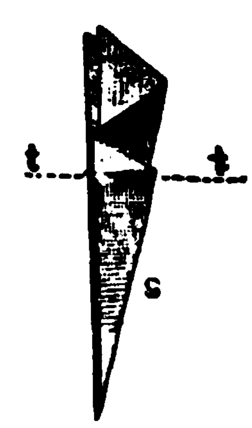
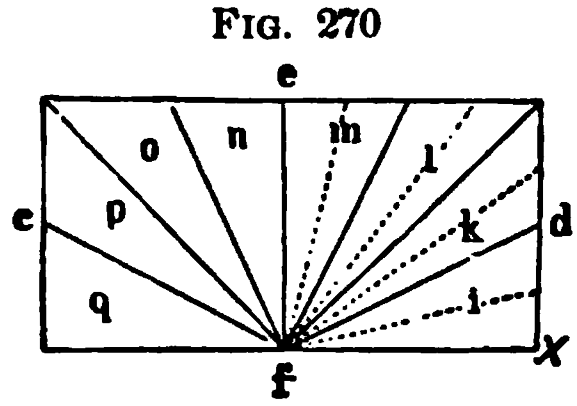


FIG. 270



Folding Filters.

rectangle (double) as shown in Fig. 270; or proceed thus: after folding to the form shown in Fig. 267, open out as shown in Fig. 266, then taking the lower corners of the edges *d* and *e*, fold them over so as to meet at *e*, thus forming a triangle, this is then laid open and each of the four triangles formed by the creasing, is again creased along the middle by bringing the sides together (inward) in the same manner; this when laid out presents the appearance of Fig. 270, the folds or creases all being bent the same direction, that is inward; then beginning at the triangle *d–f–x*, make a fold along the middle of each of the triangles (*fi–fk–fl–fm*, etc.), bending the paper back on itself in triangular form. When completed, it pre-

sents the appearance as in Fig. 271 (cut off at *t–t*); and when opened out, it appears as shown in Fig. 272.

In plaiting, care should be taken not to extend the folds entirely to the apex, but to leave about half an inch uncreased; otherwise, through the creasing, the apex may become weakened. The tips of these filters may be toughened by dipping into nitric acid (1.42 sp. gr.) and then washing well with water until the excess of acid is removed.

If, by means of a magnifying glass, we examine the structure of a piece of filter paper or filtering cloth, we will see that it is made up of fine hairs or fibres, loosely interlaced, with spaces of considerable size between. These holes are quite large, as compared with the size of the particles of the precipitates we attempt to remove from fluids. Hence in many operations it is necessary to return the first portions of the filtrate, until sufficient of the moist precipitate has collected on the skeleton of the paper or cloth to reduce the diameter of the pores or interstices, after which

FIG. 272.

Plaited Filter.

only the fluid portion will pass through. The paper or cloth simply forms a framework, on which the precipitate builds its own filter bed.

Liquids containing mucilaginous or starchy matter which refuse to pass the filter, owing to the deposit thereon of mucilage, are best managed by first straining through some coarse material, such as haircloth, which removes most of this matter, after which they may be filtered in the usual manner.

MAXIMS TO BE OBSERVED IN FILTERING.

Before pouring the liquid upon the filter, the latter should be well moistened with water, alcohol, or diluted alcohol, as the case may be.

The filter paper should never extend above, but should always end slightly below, the upper edge of the funnel.

In filling a filter, the liquid should be poured in, in a slow stream, near the upper edge, where the force will be exhausted on

the side of the filter, and not be brought to bear on the apex (Figs. 273, 274).

If the liquid contains a very fine precipitate, or is dense or hot, a double filter should be employed.

FIG. 273. FIG. 274.

Decanting Fluids on Filter.

The tip of the stem of the funnel should touch the side of the beaker or dish in which the filtrate is to be received. This hastens the flow of the filtrate and avoids any splashing.

FIG. 275

FIG. 276.

Filtering Stands.

When filtering into a bottle or flask, the funnel should be placed in the ring of a filter stand (Figs. 275, 276); or, when placed directly into the flask, sufficient space should be provided for the escape of air, which would otherwise be imprisoned, and

cause filtration to cease for a time. This may be provided for by hanging a short piece of a string or a folded strip of paper in the neck (Fig. 277), or by introducing a glass tube between the filter and funnel, reaching down into its neck.

FIG. 277.

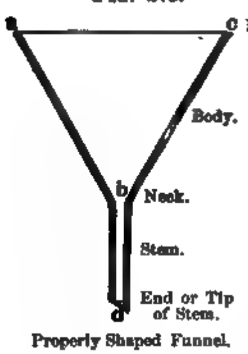
FIG. 278.

Filtering into Bottle.

Chemists' Cover.

In filtering volatile liquids, the funnel should always be covered, either with a well-fitting plate of glass, or, better, with a rubber cover (chemists' cover), provided the liquid does not act on rubber.

FIG. 279.



Properly Shaped Funnel.

FUNNELS.—A funnel is a conical-shaped utensil, the apex of which is terminated by a long stem or tube. They are used to assist in pouring fluids into narrow-mouthed receptacles and for the purposes of filtration. In a properly shaped funnel, the sides should be so inclined, that, when meeting at the neck, they form an angle of 60° (Fig. 279). The outer lines at the junction of the sides and neck form an angle of 150°. The funnels *d* and *e* (Fig. 280) are poorly shaped; in *d*, the angle of the sides is too sharp; in *e*, the neck fails to form a sharp angle with the sides.* The end of the stem of the funnel should be cut off diagonally, which facilitates the discharge of the filtrate.

Funnels are constructed of glass, porcelain, earthenware, so-called agate or granite ware, iron, tinned iron ("tin"), copper,

* For the general purposes of filtration, especially when the plaited filter is used, these requirements are not necessary. The latter refer more particularly to plain filters used in analytical operations, and that of rapid filtration, where it is absolutely necessary that the sides of the funnel should have the proper degree of inclination.

hard rubber, etc.; each has its own particular application. Copper is employed for liquors and neutral liquids, tinned iron for oils, enameled ware or earthenware for hot caustic liquids. With

FIG. 280.

Proper and Faulty Shaped Funnels.

usage, the enameling is apt to chip off and expose the iron surface, which rusts readily. The earthenware or porcelain funnels are objectionally clumsy and heavy. Tin wears off too readily and exposes the iron underneath to rust. Hard rubber funnels are very light and durable, but are objectionable because, by long use, the inner surface becomes rough, and particles of matter find an easy lodging place and are very difficult to remove, hence are liable to contaminate subsequent filtrations. For general use, glass answers best, because of its transparency and cleanliness. Funnels grooved inside (so called "fluted funnels") are also in the market for the purpose of facilitating filtration; many of these are objectionable, because of the difficulty in thoroughly cleansing them; moreover, they do not filter more rapidly than a properly made plaited filter. The ribs, to be of any value, should be deeper and spirally arranged. Circular, wire or wooden frames are also to be had for placing in a plain funnel, on which the filter is to be laid; but the wire will rust, thereby staining all preparations containing tannin; and wood will retain the odor and flavor of the different liquids filtered, thereby contaminating subsequent filtrations.

FIG. 281.

Ribbed or Fluted Funnel.

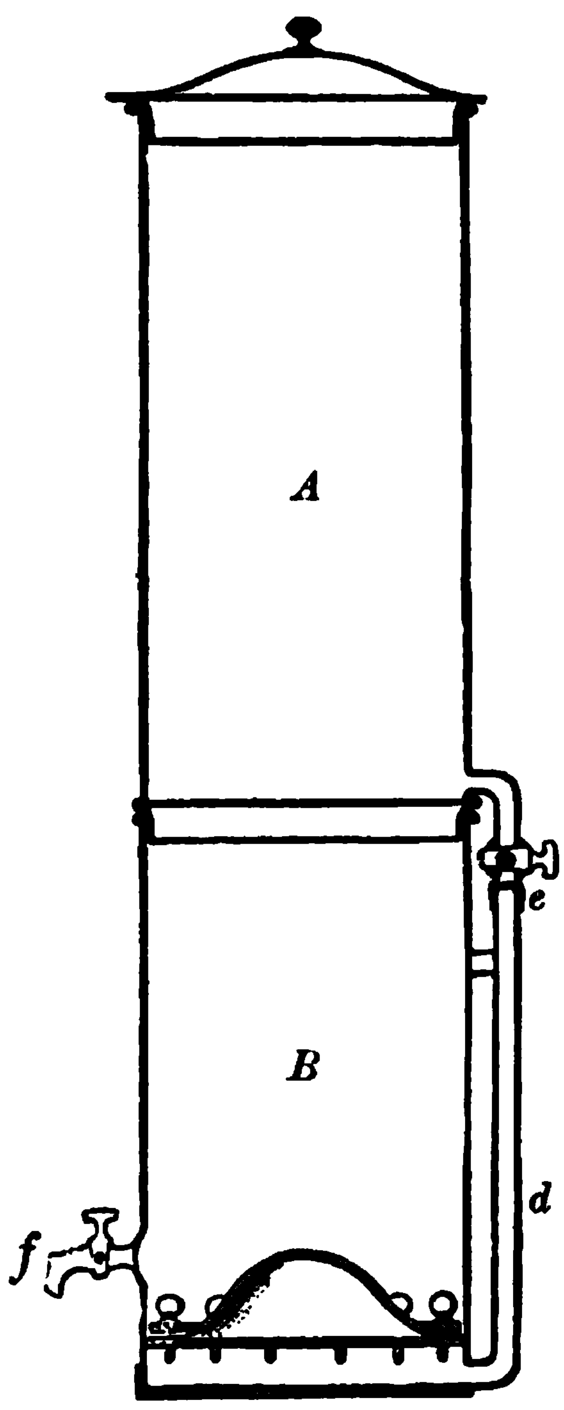
For general purposes, such as the removal of coarse mechanically suspended matter or impurities (colation), a small pledget of

absorbent cotton placed in the neck of the funnel answers very well.* It will not, however, remove finely divided suspended matter. For the filtration of acids, alkaline solutions, or corrosive liquids, *spun glass* or *fibrous asbestos* answers best.

Granulated charcoal or ground glass are sometimes used for filtering large quantities of liquids.

UPWARD FILTRATION.—For the filtration of oils and dense liquids, the filtering bag of felt has been in use for a very long time (Fig. 256). Besides this, animal charcoal, sand, sawdust, ground coke, etc., used to be employed, through which the oil or liquid was filtered. This method had the serious objection that the fluid either finds channels between the particles of the filtering medium, whereby it passes through without being filtered, or the filtration proceeds very slowly, or ceases entirely after a time, owing to the clogging of the filter from the sediment deposited. This slow and tedious method has been superseded by the method of "*upward filtration;*" but this is only adapted to the filtration of larger quantities of material. For the filtration of oils, we find an early application of this principle in the oil filter† as shown in Fig. 282. This consists of two separate cylindrical vessels: A has a flange rim of lesser diameter, soldered on the bottom, so as to fit firmly into the open top of the vessel B. To one side of the bottom of A, is attached a tube and stopcock, *c*, which fits into another tube, *d*, at *e*. Near the bottom of the lower vessel is placed a felt filter, curved upward and fastened by thumb-screws passing through two rings and the felt. The stopcock *c* is closed, and the vessel A is filled with the oil or fluid; then *c* is opened, the fluid passes down into the space below, filtering upward through the felt into B, where it is drawn off at *f*. The felt is easily removed and the bottom cleansed.

FIG. 282.



Filter for "Upward Filtration."

Fig. 283 illustrates an improved form of filtering apparatus upon the principle of which all others are constructed. The oil stored in the reservoir A flows down through the pipes, F, F, into the bottom, *a, a,* of the two filters, B, B. It is then forced upward, through a layer of felt, *b, b,* into the layer of sawdust (charcoal, coke), etc., *c, c,* which is covered with another layer of felt, on which a finely

* See page 169.

† This is sometimes called Warner's Filter.

perforated plate, *e*, rests, which can be raised or lowered by means of the screws, D, D, decreasing or increasing the pressure on the layer of sawdust. The filtered liquid is drawn out at E, E.

FIG. 283.

Apparatus for "Upward" Filtration of Oils.

Fig. 284 illustrates a method of filtering in which the fluid passes through a perforated porcelain cone fitted into the neck of a funnel. Around this cone is wrapped a layer or two of filter paper (or muslin). Then, after inserting the covered cone in the neck of the funnel, the liquid is poured in. This passes through the layers of paper into the perforations, and is discharged below. The particles of precipitate, owing to their own gravity, collect around the bottom, thus avoiding the clogging up of the filter; there is also no danger of rupturing the paper by careless pouring.

FIG. 284.

Perforated Filtering Cone.

Upon this same principle Dr. Squibb has constructed a rapid filter for the filtration of large quantities of liquids. A rectangular wooden box is taken (dimensions about 30 × 18 × 6 inches), all the sides are pierced full of holes, leaving the bottom intact; one hole is bored in the top for admitting a siphon. Around the box are wrapped, alternately, layers of muslin and filter paper, the outside layer being muslin, secured by stitching. This box is then immersed in the vat of liquid to be filtered; the fluid filters rapidly through into the box, whence it is drawn off continuously by means of a glass siphon. The muslin sides of the filter may be brushed, should they show a tendency to clog from the collection of the precipitate.

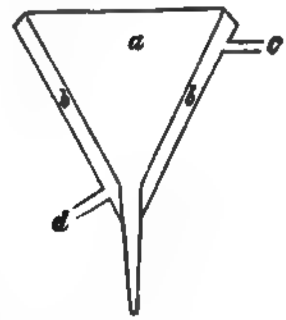
HOT FILTRATION.—Dense liquids, such as syrups, oils, fats, gel-

atin solutions, or such solutions as are prone to crystallize while

FIG. 285.

Jacketed Funnel.

FIG. 286.



Dieterich's Jacketed Funnel (for Steam).

cooling, are filtered while hot; this is conveniently accomplished by employing the jacketed funnel (Fig. 285), which is double-walled, made of tin or copper. It is filled through an opening in the top and heated at the projecting flange. Fig. 286 illustrates a form proposed by Dieterich, which is heated by passing steam in at *c*, which circulates about the sides, *b b*, escaping through *d*. Another form (Fig. 287) consists of a worm of lead or brass pipe, coiled in the form of a cone having an angle of 60°, so as to adapt itself closely to the sides of the funnel. The coil is intended to be charged with steam, to avoid the close proximity of a flame, when inflammable liquids are to be filtered. The steam may be generated as shown in Fig. 153, the apparatus being placed some distance from the funnel if necessary.

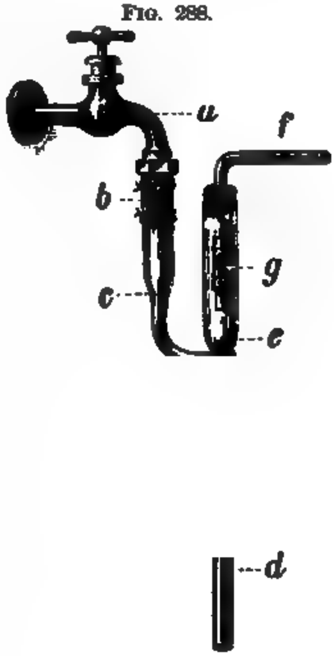
FIG. 287.

Liebreich's Steam Coil Jacket for Hot Filtration. *g*. Funnel. *b*. Pipe Coil.

RAPID FILTRATION (Pressure Filtration).—To promote the rapidity of filtration, particularly in cases of dense or mucilaginous liquids, a partial vacuum may be produced and maintained beneath the filter paper. For this purpose various forms of filter pumps are used in the laboratory; in these pumps, water is ejected from a small tube having a pointed orifice, placed within another tube communicating with the vessel into which the funnel is fitted air-tight. The continuous, strong jet of water aspirates the air contained in the vessel, and thereby causes the

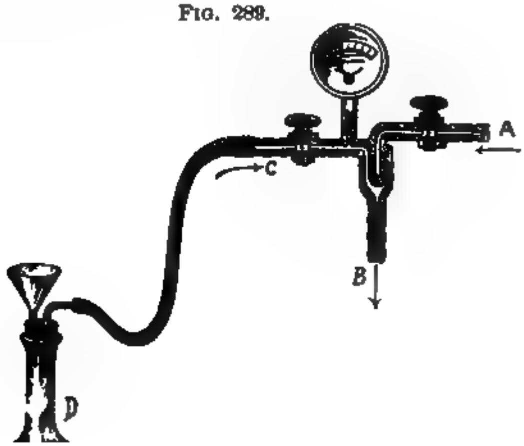
liquid to pass rapidly through the filter. The construction of these pumps is very simple, as may be seen in that made of glass, shown in Fig. 288. The water entering at *b c*, under pressure, is forced out at rapid rate through *d*, causing suction in *e f;* the rubber valve, *g*, regulates the pressure and prevents the back-flow of water through *f* into the apparatus. Fig. 289 illustrates such an apparatus in operation; it consists of a flask, D, into which is tightly fitted, by means of a rubber stopper, a funnel and an exit tube for the withdrawal of air, which is accomplished by means of the vacuum pump; the water enters the pump at *A*, and is discharged through *B* with considerable force, withdrawing the air from the flask by suction through *C*. Then the pressure exerted by the atmosphere upon the surface of a liquid in the funnel, forces it rapidly through. The more expensive form of a pump with the indicator (indicating the pressure), may be replaced by the cheaper forms made of glass.

FIG. 288.



Water Pump.

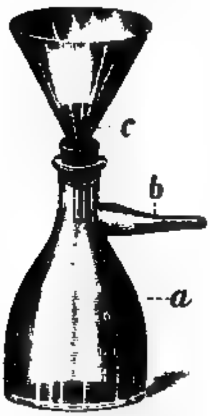
FIG. 289.



Rapid Filtration.

The stopper should be of rubber and firmly fitted in the neck of the flask; to prevent the filter paper from being ruptured at the point, a perforated cone of thin metal (platinum) is first placed in the bottom of the funnel, and into this is placed the plain filter (preferably double) and moistened, care being taken that it fits the sides closely, so as not to admit air through furrows. It is next filled with the fluid, and the suction pump then started, slowly at first and gradually increasing. The cone of platinum may be replaced by a piece of muslin folded like a plain filter, or a so-called "toughened" or "hardened" filter may be used. During filtration, usually by the sudden removal of pressure,

FIG. 290.



Suction Flask for Rapid Filtration.
c. Perforated cone.
b. Side tube connected with pump.

FIG. 291.

Funnel with Perforated Disc.

FIG. 292.

Improved Porous Filtering Plate.

water may sometimes be drawn over into the filtrate (in the flask). This can be avoided by interposing an empty bottle by means of tightly fitting connections between the pump and filtering flask. Where a powerful suction is obtainable, rapid filtration may be effected by placing a Witt's perforated porcelain disc (with ground slanting edge) in the funnel (Fig. 291); this is then covered with a piece of filtering paper cut slightly larger than the disc, the edges extending about one-fourth of an inch up the sides of the funnel. This is then moistened, the suction gently started, and the filtering paper closely pressed to the sides of the funnel, so that when the liquid is poured in, the sediment may not be drawn down behind the paper. This form of filtration is best

adapted to the collection and washing of precipitates. Fig. 292 illustrates an improvement in which a rubber ring is stretched around the edge of the plate to obtain a more secure joint at *c*; the rod *a* is intended to assist in keeping the plate in position.

Fig. 293 illustrates a convenient method where special appliances

Fig. 293.

Rapid Filtration (Improvised Apparatus).

are wanting; the two aspirators, A, B, are connected by a rubber tube; A is filled with water and connected with the flask C, to which is fitted the funnel for filtering. The water is then allowed to flow down from A to B; this causes the withdrawal of air from C; the higher A is above B, the greater the suction. When the bottle B is full, it is simply interchanged for A, and the flask containing the filter connected with B.

CHAPTER XX.

CLARIFICATION.

Many liquids contain finely divided suspended matter which interferes with their transparency, and which cannot be removed by filtration. In such cases we must resort to treatment with some insoluble substance which will attract or envelop these particles. This operation is called *Clarification.*

There is a kind of clarification which may be called "spontaneous clarification," or "clarification by subsidence," which may be employed in many cases. It consists in allowing the liquid to stand in a quiet place for a sufficiently long time, until the suspended matter has settled to the bottom.

When time is a consideration we resort to artificial clarification.

This may be accomplished in several ways:—

Through the Agency of Heat.—Viscid liquids of the nature of Canada Balsam or Honey, when heated become more fluid; this enables the solid suspended particles, which interfere with their transparency, to either rise to the surface or fall to the bottom, provided the liquid is allowed to remain perfectly quiet for a time. The impurities which rise to the surface may be removed by skimming, while the sediment is removed by straining. Some liquids like the fruit juices or aqueous vegetable solutions contain albuminous matter which interferes with their transparency; when these are heated to boiling, the albumen is coagulated and can be removed by straining.

By the Use of Albumen.—When albumen is not already present in the liquid, it may be added; this when boiled with the aqueous solution coagulates, enclosing thereby the particles of suspended matter mechanically, causing them to rise to the surface as a scum, which is then removed by skimming or straining. The white of an egg (one for each gallon), is first well diluted with a portion of the liquid, the mixture well beaten, and then added to the balance, which after being well shaken or mixed, is heated gradually to the boiling point, when the coagulated matter is skimmed off. Albumen should not be used for alcoholic liquids, or for solutions which contain substances that unite with albumen forming insoluble compounds, such as salts of mercury, lead, copper, or tannic acid, etc.

By the Use of Gelatin.—This is employed in removing suspended matter due to the presence of tannin-like substances. It readily unites with these, forming an insoluble leather-like compound. To the cold liquid is added a solution of isinglass;

the whole is well mixed, heated to boiling, and on cooling it is strained or filtered. Gelatin is not adapted to alcoholic liquids or solutions whose activity depends on tannic acid.

By the Use of Insoluble Bodies.—Calcium Phosphate or Magnesium Carbonate, Talcum or Paper Pulp are usually employed for this purpose. The powders answer admirably for clarifying neutral liquids; in this case a small quantity is triturated to a paste with the fluid, the rest being added gradually, and the whole is then filtered through a plain or plaited filter.

Paper pulp acts mechanically like the preceding, but is not so satisfactory. The pulp is added to the liquid, the mixture well shaken and poured on the filter, the first portions of the filtrate being returned to the filter, until the liquid runs through clear. The pulp may be prepared by pouring a hot solution of caustic soda over cut filter paper, reducing it to a pulp by means of a pestle, then washing thoroughly with hot water, until all traces of alkali have been removed; that is, until the wash water fails to turn red litmus blue, or phenolphtalein red.

By the Use of Alcohol.—This coagulates slimy and mucilaginous substances. Hence, when added to liquids containing these matters, it causes a coagulum to separate which carries the suspended matter along with it. After filtration, the alcohol is driven off by heat. Alcohol plays the part of a clarifying agent, in the clarification of fruit juices, and, owing to the manner in which it is generated, the operation is designated as *clarification by fermentation.* This method is based on the transformation of the fruit-sugar contained in the expressed juice into alcohol, through the action of a micro-organism called the *saccharomyces cerevisiæ.* The conversion of the fruit-sugar into alcohol is termed vinous or saccharine fermentation. For this purpose the expressed juice is placed in a room where the temperature varies from 20 to 25° C., until vinous fermentation has taken place; this requires about forty-eight hours, after which the liquid is heated to boiling and strained. If the fluid is allowed to stand too long, then acetic fermentation begins, whereby the alcohol is converted into acetic acid, this must be avoided.*

* A powder for clarifying wines, liquors, essences, etc., may be made by mixing 40 parts each of finely powdered egg albumen and milk-sugar with 20 parts of starch in fine powder. To each liter of the fluid, 5 grammes of this powder is added, and after thorough agitation, the mixture is set aside for several days and then filtered.

CHAPTER XXI.

DECOLORATION.

The process of depriving liquids of color by filtration through some substance capable of absorbing organic coloring matter, usually animal charcoal.

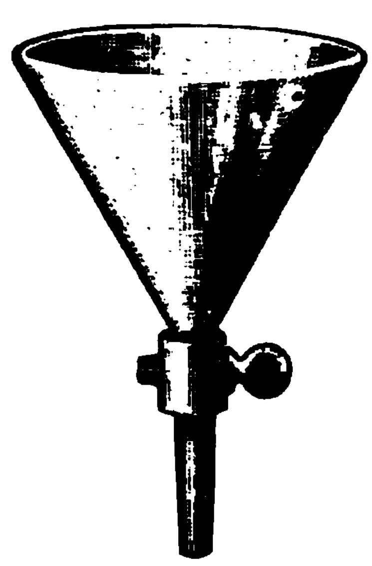
The object of decoloration is to remove the coloring matter and impurities accompanying vegetable principles such as alkaloids, glucosides, or bitter principles. It is resorted to particularly for decolorizing syrups in sugar refining, and cotton-seed oil; for the removal of color from petroleum residues, in the manufacture of petrolatum, and petroleum jellies. Formerly precipitated iron or aluminium hydrate were used to some extent as decolorizing agents. Animal charcoal is made by heating bones, in closed retorts, out of contact with air; the product is then reduced to a granular condition by grinding. The best qualities are made from dried blood. Powdered animal charcoal is often called bone-black. When of good quality, it should, upon being boiled with solution of potassa, not impart any color to the liquid. It consists of carbon (about 10 per cent.), calcium phosphate and carbonate, aluminum and iron hydroxides, and silica (about 90 per cent.). Its decolorizing powers were supposed to be due to the minute state of division of the carbon, or to its physical condition, as an aggregation of cellular spaces; however, recent investigations tend to show that the impurities in the animal charcoal play a large, if not the largest, part in the decolorizing power. In view of this, Stenhouse has prepared an *aluminized charcoal*, made by impregnating finely powdered wood charcoal with 7½ per cent. of alumina, drying, and igniting. He also prepared an *artificial bone black* by impregnating powdered charcoal with 7½ per cent. of calcium phosphate. These prepared charcoals decolorize well, but can be used only for neutral solutions. After being once used, animal charcoal may be washed with dilute acids, re-burnt out of contact with air, and again used; in fact, it may be used many times over, although its decolorizing powers gradually become weaker. Solutions of plant principles which are to be decolorized are either digested with, or percolated through it. Since it has a tendency to retain such principles, the charcoal should afterward be boiled with some of the solvent, for instance, alcohol, which extracts the principle retained.

CHAPTER XXII.

SEPARATION OF IMMISCIBLE LIQUIDS.

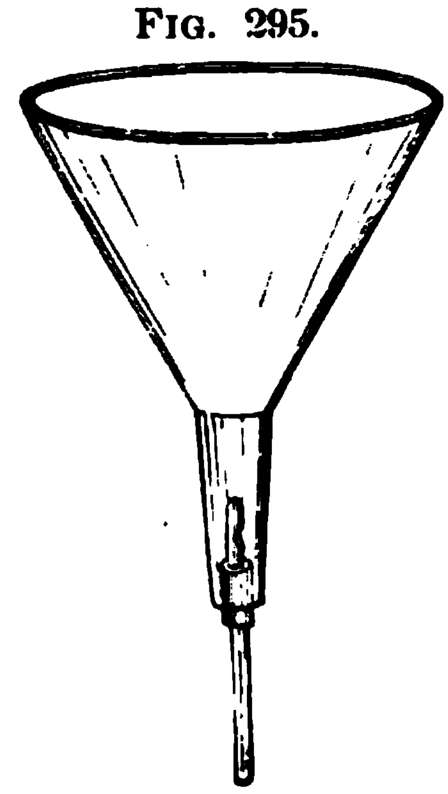
The pharmacist occasionally has to separate immiscible liquids; for instance, in the washing or purification of oils (volatile and fixed), which have become resinified or partially rancid. He has also occasion to separate immiscible volatile solvents (ether, chloroform, benzin, etc.), from aqueous solutions. In the first instance, after the oil has been thoroughly washed, by agitation in a closed flask with water (slightly alkaline), the mixture is poured into an open separating funnel (Fig. 294) and allowed to stand until it has separated into two clear layers, then the underlying water or oil may be slowly and carefully drawn off. Fig. 295 illustrates a home-made separating funnel designed by C. O. Currier. The liquid is drawn off by means of a glass tube, sliding through a cork. Near the closed end of this tube a hole is filed through, by means of a rat-tail file (moistened with oil of turpentine); then, by raising or lowering the tube, the respective liquids may be drawn off.

FIG. 294.



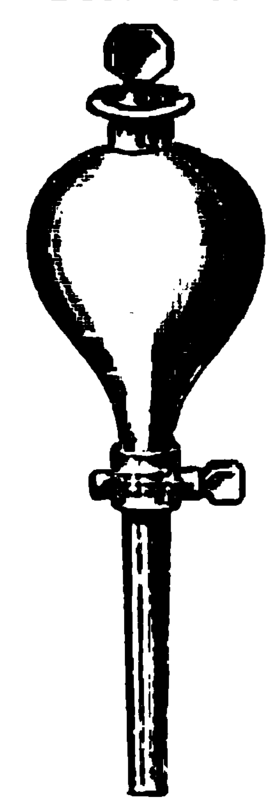
Separating Funnel (stoppered).

FIG. 295.



Separating Funnel (Currier).

FIG. 296.



Separating Flask (pear-shape).

For all kinds of operations, the so-called "separator," or separating flask provided with a glass stopper, is to be preferred (Fig. 296). This consists of a pear-shaped or cylindrical bulb provided with a well-ground, perforated stop-cock and a short exit-tube. This form is usually employed in the various operations of shaking aqueous liquids with volatile solvents, which is necessary in the preparation of various pharmaceutical products and in the assay of alkaloidal drugs. When such separators are

not available, the agitation may be performed in a glass-stoppered bottle, and the fluids separated by means of a pipette, the point of which is drawn out to a capillary (Fig. 297). Over the top of these small pipettes an unperforated rubber nipple may be drawn, which may be used as a means of suction instead of the mouth.* In operating upon larger quantities of liquids, they may be separated readily and completely, by means of a siphon which is operated by forcing air into the flask. The arrangement in Fig. 298 is adapted for the withdrawal of the lower fluid, and in order that none be lost, the tube is bent so that it can be shoved into the edge of the bottom when the flask is inclined. For drawing off the upper fluid (Fig. 299) the siphon, which has a hook at the shorter extremity, is raised to the lower level of the floating fluid.

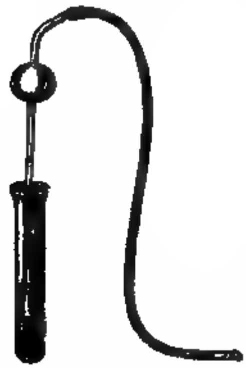
FIG. 297.

Separation of Fluids by Capillary Pipette.

FIG 298. FIG. 299.

Separation of Immiscible Fluids by Siphon.

* See Pipettes, page 164.

CHAPTER XXIII.

EXTRACTION.

This term is applied to any process whereby the soluble matter of complex drugs, usually vegetable, are separated from the insoluble portion by means of a solvent: when practically accomplished, the drug is said to be *exhausted*. This is carried out in the operations of maceration or digestion, percolation, or a combination of both.

MACERATION.

Maceration consists in subjecting a drug, reduced to a coarse powder, to the solvent action of a selected liquid, called the menstruum, the length of time and temperature being an important consideration. The temperature employed in different pharmacopœias varies from 10° to 100° C., being accordingly designated as maceration, digestion, infusion, or decoction.

When a moderate heat (30–40° C.) accompanies maceration, it is called *digestion*.

Maceration for a short time, either in cold, lukewarm, hot, or boiling water, and subsequent straining, is called *infusion*.

When the mixture of drug and water is boiled together, it is called *decoction*.

The temperature of maceration, in the preparation of tinctures, wines, vinegars, etc., as directed by most pharmacopœias is from 15° to 20° C. The length of time is from 1 to 36 hours, according to the nature of the drug and menstruum; where the process of percolation is not employed, the time of maceration is usually extended to the period of a week or more.

In the manufacture of pharmaceutical preparations, when the drug is to be exhausted by a fluid menstruum, as in the preparation of tinctures, extracts, wines, vinegars, etc., two methods of extraction are employed, either that of *maceration*, or that of *percolation*. The process of maceration is employed almost exclusively by the European apothecaries, who claim that it possesses the following advantages over the method of percolation.

By maceration, the drug is more evenly exhausted, and the products obtained are of like and uniform composition and are more stable.

It affords excellent results every time a substance is to be exhausted and with the smallest possible quantity of menstruum.

It is far less expensive, since the loss in alcohol is very slight, the chief opportunity for any loss being during the operation of expressing the residue.

Preparations made by percolation are less stable, being more liable to precipitate, and especially so if water is used for forcing out the last portions of alcoholic menstruum, for then a diffusion of the two cannot always be avoided.

Maceration answers best for inexperienced hands, since the operation of percolation requires skill, with careful and constant supervision, in consequence of the wide variation in the nature and structure of different drugs.

It does not necessitate the pulverization of the drug, thereby dispensing with previous desiccation and possible loss, by alteration or destruction, of volatile principles, as, for instance, in conium, lobelia, physostigma, etc.

On the other hand, it is claimed that the process of maceration involves considerable loss. Yet, when the operation is carefully managed, the loss is not any greater than by the process of percolation.* For further references concerning the process of maceration, see Tincturæ and Extracta Fluida.

Percolation is *not* adapted to certain kinds of drugs, particularly those of a spongy nature, which tend to swell with aqueous or hydro-alcoholic menstrua, and render the passage of the fluid slow and difficult; as examples, arnica flowers and orange-peel may be cited.

Percolation is well adapted to such drugs as aconite root, cinchona bark, ergot, etc., but, wherever applied, the process demands care and skill.

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* Economic Percolation by Arny, "Proceed. A. P. A., '92," p. 169.

CHAPTER XXIV.

PERCOLATION.

Percolation, or displacement, is the process of extraction of a drug by the gradual descent of a solvent. It is called *displacement* because the solvent, after becoming charged with the soluble constituents of the drug, is displaced by fresh portions of the solvent liquid, and from its own gravity, and by the presence of the liquid above, minus capillary force, continues downward and is discharged below.

Percolation, when *properly carried* out, is an effective and expeditious process of drug extraction. It yields at once, without further manipulation, a finished product. The product is called the *percolate*, and the vessel in which the operation is carried on, the *percolator*, and the liquid solvent employed is called the *menstruum*.

FIG. 300.

Real's Press (Percolator).

The earliest and simplest application of the process of percolation was that embraced in the old process of *lixiviation*, which consists in depriving wood ashes of their soluble matter, by pouring water over them, when placed in a cylindrical or conical vessel.

Count Rumford, in 1813, used percolation in making coffee decoction, but the first application of this process to the extraction of drugs was made by Count Real in 1815, who invented a so-called press (Fig. 300), which consisted of a metallic cylinder, tapered below to a narrow neck, which was provided with a stopcock. In the bottom of this cylinder was a perforated diaphragm, upon which the drug was to be packed, entirely filling the apparatus. The top

is covered with a tightly fitting cap, connected with an upright tube, from 2½ to 3½ meters long, enlarged to a cup-shaped opening above. This was employed in making infusions, in which the main difficulty experienced was, owing to the great pressure produced by the height of such a column of liquid, that the menstruum flowed through without completely exhausting the drug. Later (1817) it was used by Johnson in the extraction of cinchona, but to Boullay frères (1833) belongs the credit of fully demonstrating its practical value in pharmacy. While the process was making rapid progress in France, Messrs. Duhamel, Proctor, and Grahame were carrying on experiments in America, which finally led to its first introduction into the U. S. Pharmacopœia of 1840, where it was made official as an alternative process. Since that time, great progress has been made in bringing this process to a greater state of perfection through the labors of Proctor, Squibb, Lloyd, and others. The process, while being employed exclusively in our own Pharmacopœia in the preparation of its tinctures, fluid extracts, etc., has received until within recent years, comparatively little attention from the European pharmacopœias, where the process of maceration is still employed almost exclusively.

The U. S. Pharmacopœia gives the following definition and description of the process:—

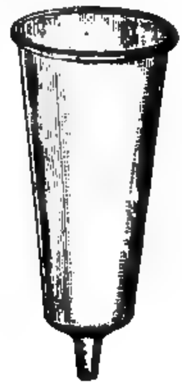
"The process of percolation, or displacement, directed in this Pharmacopœia, consists in subjecting a substance or a mixture of substances, in powder, contained in a vessel called a percolator, to the solvent action of successive portions of a certain menstruum in such a manner that the liquid, as it traverses the powder in its descent to the receiver, shall be charged with the soluble portion of it, and pass from the percolator free from insoluble matter.

"When the process is successfully conducted, the first portion of the liquid, or percolate, passing through the percolator, will be nearly saturated with the soluble constituents of the substance treated; and if the quantity of menstruum be sufficient for its exhaustion, the last portion of the percolate will be nearly free from color, odor, and taste, other than those of the menstruum itself."

In order to be able to apply the process of percolation intelligently, so as to secure the object aimed at, viz., the extraction of the useful soluble constituents of a drug, the operator must have some knowledge of the structure and composition of the drug. In its natural, unpowdered condition, the drug (assuming it to be of organic origin) is usually made up of cells and vessels of various shapes and of interstitial spaces. When the drug is powdered, many of these cells and vessels, which usually contain the matters to be extracted, are broken up, and the interstitial spaces are thus largely increased in number. If the powdered mass is now to be extracted by a menstruum, not in repose, but slowly passing through the mass, it is necessary to adjust the current so that the menstruum has time to penetrate the solid

particles, to become charged with the soluble matters contained therein, and to be slowly displaced by fresh portions of the menstruum. If the current of the menstruum is so rapid that the latter has not sufficient time to penetrate and pass through the solid particles, there will be a deficiency in the product. The best plan of avoiding this is to give ample time to the menstruum, particularly in the beginning, to penetrate the solid substance and to render the cell-walls ready for the process of osmosis. Hence the first step, in percolation, is to moisten the powder and to wait until the liquid has thoroughly penetrated the solid particles themselves. In some drugs this is accompanied by a considerable swelling, or increase of volume, due to their spongy or mucilaginous nature. In these cases it is particularly necessary to wait for complete expansion, since, otherwise, the drug would so clog the percolator that no liquid would be able to pass.

FIG. 301. FIG. 302. FIG. 303.



Cylindrical Glass Percolator. Conical Glass Percolator. Metal Percolator.

"The percolator most suitable for the quantities contemplated by the Pharmacopœia should be nearly cylindrical, or slightly conical, with a funnel-shaped termination at the smaller end. The neck of this funnel-end should be rather short, and should gradually and regularly become narrower toward the orifice, so that a perforated cork, bearing a short glass tube, may be tightly wedged into it from within until the end of the cork is flush with the outer edge of the orifice. The glass tube, which must not project above the inner surface of the cork, should extend from 3 to 4 Cm. beyond the outer surface of the cork, and should be provided with a closely fitting rubber tube, at least one-fourth longer than the percolator itself, and ending in another short glass tube, whereby the rubber tube may be so suspended that its orifice shall be above the surface of the menstruum in the percolator, a rubber band holding it in position.

"The shape of a percolator should be adapted to the nature of the drug to be operated upon. For drugs which are apt to swell, particularly when a feebly alcoholic or an aqueous menstruum is employed, a *conical* percolator is preferable. A *cylindrical* or only slightly tapering percolator may be used for drugs which are not liable to swell, and when the menstruum is strongly alcoholic, or when ether or some other volatile liquid is used for extraction. The size of the percolator selected should be in proportion to the quantity of drug extracted. When properly packed in the percolator, the drug should not occupy more than two-thirds of its height. The percolator is best constructed of glass or stone-ware, but, unless otherwise directed, may be made of any suitable material not affected by the drug or menstruum."

While not specifying dimensions, the Pharmacopœia directs the employment of either one of two forms, the *conical* or *cylindrical.* In percolating such drugs as are liable to swell considerably, for instance, gentian, calumba, rhubarb, etc., or where the menstruum is more aqueous than alcoholic, the conical form is preferred; since, owing to the slanting of the sides, the drug has an opportunity to expand upward. Also, since these drugs yield to an aqueous menstruum a large amount of soluble and mucilaginous matter, it cannot as readily collect as a viscid liquid, and retard percolation, as is often the case in the cylindrical form. In all other cases the tall and narrow cylindrical percolator is preferred, which increases the height of the column of the drug and menstruum in proportion to their mass, thus insuring the thorough exhaustion of the drug with a moderate quantity of menstruum.*

"The percolator is prepared for percolation by gently pressing a small tuft of cotton into the neck above the cork, a thin layer of clean and dry sand being then poured upon the surface of the cotton to hold it in place."

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* VARIOUS DIMENSIONS FOR THE DIFFERENT SIZES OF THE OLDBERG CYLINDRICAL PERCOLATOR.

	Approximate Capacity.		Length of Body.		Internal Diameter at the Top.		Internal Diameter of Body at the Shoulder.		Depth of Shoulder.		Length of Stem (or Neck).		Internal Diameter of Stem at the Throat.		Internal Diameter of Stem at Mouth or Exit.		Length of Rubber Tube.		
Numbers.	Cc.	U. S. Fluid Measure.	Millimeters.	Inches.	Millimeters.	Inches.	Millimeters.	Inches.	Millimeters.	Inches.	Millimeters.	Inches.	Millimeters.	Inches.	Millimeters.	Inches.	Millimeters.	Inches.	Numbers.
2	150	5 fl. oz.	180	7.09	36	1.417	30	1.181	6	.236	30	1.181	10	.394	12	.472	240	9.45	2
3	240	8 "	210	8.27	42	1.654	35	1.378	8	.315	30	1.181	10	.394	12	.472	280	11.02	3
4	360	12 "	240	9.45	48	1.890	40	1.575	10	.394	30	1.181	10	.394	12	.472	320	12.60	4
5	530	18 "	270	10,63	54	2.126	45	1.772	12	.472	35	1.378	13	.512	15	.591	360	14.17	5
6	740	25 "	300	11.81	60	2.362	50	1.968	14	.551	35	1.378	13	.512	15	.591	400	15.75	6
7	1,240	42 "	360	14.17	72	2.835	60	2.362	16	.630	35	1.378	13	.512	15	.591	480	18.89	7
8	1,960	66 "	420	16.53	84	3.307	70	2.756	18	.709	35	1.378	13	.512	15	.591	560	22.05	8
9	3,000	100 "	480	18.89	96	3.780	80	3.150	20	.787	35	1.378	13	.512	15	.591	640	25.20	9
10	3,780	8 pts.	540	21.25	108	4.252	90	3.543	22	.866	35	1.378	13	.512	15	.591	720	28.35	10
11	5,700	12 "	600	23.62	120	4.724	100	3.937	24	.945	35	1.378	13	.512	15	.591	800	31.50	11
12	7,600	16 "	660	25.98	132	5.197	110	4.331	26	1.024	35	1.378	13	.512	15	.591	880	34.65	12

In preparing the percolator, care should be taken not to press the wad of cotton too tightly. It should fit loosely into the upper portion of the neck, partly covering the bottom of the percolator; it is preferable to cover this with a disc of filter paper cut to fit the bottom of the percolator. This may be covered with a layer of clean sand, or pebbles. Some operators prefer to insert a cork, grooved all around, into the upper part of the neck, and to cover this directly with a disc of filter paper. Where obtainable, glass-wool will be found far better than cotton for this purpose, since it retains its spongy condition and does not fall together on becoming wet. In selecting the proper-sized percolator, we must be guided by the amount of drug; thus, if the percolator be large enough for 16 troy ounces, we should not use it for 8 or 10 ounces of drug, and, upon the other hand, the percolator must be amply large enough to accommodate a good supply of menstruum above the surface of the powder.

"The powdered substance to be percolated (which must be uniformly of the fineness directed in the formula, and should be perfectly air-dry before it is weighed) is put into a basin, the specified quantity of menstruum is poured on, and it is thoroughly stirred with a spatula, or other suitable instrument, until it appears uniformly moistened. The moist powder is then passed through a coarse sieve—No. 40 powders, and those which are finer, requiring a No. 20 sieve, whilst No. 30 powders require a No. 15 sieve for this purpose. Powders of a less degree of fineness usually do not require this additional treatment after the moistening. The moist powder is now transferred to a sheet of thick paper and the whole quantity poured from this into the percolator. It is then shaken down lightly and allowed to remain in that condition for a period varying from fifteen minutes to several hours, unless otherwise directed; after which the powder is pressed, by the aid of a plunger of suitable dimensions, more or less firmly in proportion to the character of the powdered substance and the alcoholic strength of the menstruum; strongly alcoholic menstrua, as a rule, permitting firmer packing of the powder than the weaker. The percolator is now placed in position for percolation, and, the rubber tube having been fastened at a suitable height, the surface of the powder is covered by an accurately fitting disc of filtering paper, or other suitable material, and a sufficient quantity of the menstruum poured on through a funnel reaching nearly to the surface of the paper. If these conditions be accurately observed, the menstruum will penetrate the powder equally until it has passed into the rubber tube and has reached, in this, a height corresponding to its level in the percolator, which is now closely covered to prevent evaporation. The apparatus is then allowed to stand at rest for the time specified in the formula.

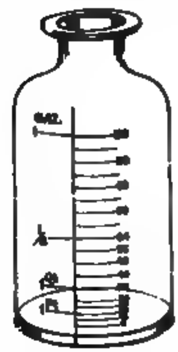
"To begin percolation, the rubber tube is lowered and its glass end introduced into the neck of a bottle previously marked for the quantity of liquid to be percolated, if the percolate is to be

measured, or of a tared bottle, if the percolate is to be weighed; and by raising or lowering this receiver the rapidity of percolation may be increased or decreased as may be desirable, care being taken, however, that the rate of percolation, unless the quantity of material be largely in excess of the pharmacopœial quantity, shall not exceed the limit of ten to thirty drops in a minute.* A layer of menstruum must constantly be maintained above the powder, so as to prevent the access of air to its interstices, until all has been added, or the requisite quantity of percolate has been obtained. This is conveniently accomplished, if the space above the

FIG. 304.

Percolation.†

FIG. 305.



Receiving Jar.

powder will admit of it, by inverting a bottle containing the entire quantity of menstruum over the percolator in such a manner that its mouth may dip beneath the surface of the liquid, the bottle being of such shape that its shoulder will serve as a cover for the percolator."

DEGREE OF FINENESS OF THE POWDERED DRUG.—It is essential

* The rate or speed of percolation may be increased in proportion to the *amount* of drug percolated.

† Fig. 304 illustrates the official operation of percolation. It also illustrates the solvent action of the menstruum in its descent; the portion, *c-d*, containing the largest amount of extractive, is followed by the layer *d-e*, containing less, and *e-f*, the least amount of extractive. In actual operation the lines of demarcation are not so sharp, but gradually blended from below upward.

that the drug be of a proper and uniform degree of fineness; when it is too coarse, complete exhaustion does not take place; when it is too fine, percolation ceases from agglutination, and when it is not of uniform fineness, percolation is hindered. The fineness of the powder must be in accordance with the nature of the drug and solvent. Drugs like rhubarb and gentian, which have an open, loose cellular structure, and whose constituents are readily soluble, are easily exhausted when in coarse powder. Such drugs as nux vomica and ignatia have a hard, horny structure, which is not easily penetrated by a solvent, hence they must be reduced to a fine powder. The finer the powder, the more intimate will be the contact with the solvent; hence, in the preparation of fluid extracts, we employ as fine a powder as is consistent with the nature of the drug, while in the case of tinctures, where the amount of menstruum is large in comparison to the drug, we employ a coarser powder.

Moistening and Packing.—A drug should be thoroughly moistened and permitted to expand before being packed, so that the dry cellular tissue may, from the absorption of liquid, swell to its ultimate condition, and that, after the drug is packed, the liquid may pass in an even current. If a drug is packed without having been moistened, or before it has ceased to swell, and menstruum then poured upon it, the passage of the latter would soon be obstructed by the swelling of the particles. After being moistened, the powder should be rubbed through a coarse sieve so as to secure uniformity of texture and to prevent any balling. After this, it may be either poured into the percolator, which is to be carefully covered so as to prevent the powder from drying out, or placed in a well-closed, wide-mouthed macerating jar. It is then allowed to stand for a period varying from fifteen minutes to several hours, according to the nature of the drug.

The powder is now "packed" in the percolator, which is done by introducing it in portions, distributing it uniformly and evenly, and applying a more or less strong pressure, according to the directions, in such a way, however, that the pressure always diminishes toward the surface. The directions given by the Pharmacopœia, viz., "to pour the powder into the percolator, to shake it down carefully so as to avoid the formation of furrows or cavities, and then to apply pressure on the surface," are liable to produce difficulties during the percolation. The firmness with which a powder should be packed, depends entirely on the structure of the drug and on the menstruum employed. If the drug be porous and spongy and the menstruum aqueous, it should be packed loosely; if the menstruum be alcoholic, it should be packed firmly. As a rule, the more alcoholic the menstruum, the firmer should be the packing.

After the powder has been properly packed, a circular piece of filter paper (nicked around the edges), slightly larger than the

diameter of the upper layer of powder, is laid upon the surface, and weighted with pebbles, broken glass, a funnel, or a glass tripod weight* made for this purpose. As much menstruum should be added at once as the percolator will hold, great care being always taken not to allow the menstruum to disappear below the surface of the powder; for should this take place, air will be drawn into the interstices of the drug and fissures will form by contraction of its mass; hence, when more menstruum is added, it will flow through those parts where it meets the least resistance, seeking the fissures which allow the passage of the menstruum through these channels, instead of percolating through the powder. When constant attention cannot be given to the operation, a flask may be inverted over the top of the percolator, as shown in Fig. 304, or the device illustrated in Fig. 252 may be employed, or else the process may be interrupted by stopping the flow of the percolate.

After the menstruum has been added (if the drug has been properly packed), it will permeate the powder and descend at a uniform rate throughout the mass. Should it descend more rapidly on one side than on the other, this would be due to irregular packing, indicating that too little pressure has been used on one side as compared with the other, and then a portion of the powder will not be as thoroughly exhausted as that more loosely packed, owing to the rapidity with which the menstruum passes through the more porous portion.

Under proper conditions, after the menstruum has penetrated the entire powder, and passed into the rubber tube, the mouth of the percolator is to be covered to prevent evaporation, and allowed to stand at rest for the time specified by the formula. The length of this period of maceration depends on the nature of the drug and the amount of menstruum. Should the amount of menstruum be small, as in the preparation of fluid extracts, a greater length of time is necessary than in the making of weaker preparations, such as tinctures, wines, etc., for with these the length of maceration may be short, since we have a large amount of fluid with which to exhaust a small amount of drug.

Proper Menstruum.—A knowledge of the constituents of a drug, and of their properties, is absolutely necessary before the proper menstruum for percolation can be selected. The menstruum must be so chosen as to extract the active principles, and yet take up as little as possible of the inert matter. The menstruum must also be capable of holding the extractive matter permanently in solution. Such drugs as contain alkaloids, resins, etc., require a more strongly alcoholic menstruum. Such as licorice require a slightly alkaline hydro-alcoholic menstruum. Such as ergot, sanguinaria, conium, etc., are better exhausted with an alcoholic menstruum slightly acidified. In many cases glycerin is added, since it has intermediate solvent properties between those of alcohol

* Made by Messrs. Whitall, Tatum & Co.

and water, and dissolves all principles soluble in either alone. In the case of gentian, scoparius, and quassia, just enough alcohol is employed to prevent fermentation of the finished preparation.

Exhaustion.—The Pharmacopœia directs that displacement be continued until the drug is exhausted. The exhaustion of a drug cannot be insured with a given amount of menstruum, for that depends entirely upon the skill of the operator. In this case, we must be guided by the nature or peculiarities of the drug operated upon. When the active principles possess a bitter taste, as in nux-vomica, cinchona, or quassia, exhaustion is indicated by the disappearance of a prominent bitterness. In the case of resinous drugs, such as podophyllum or jalap, the percolation is to be continued until the percolate ceases to produce cloudiness when dropped into water. With astringent drugs, such as catechu or krameria, we judge the drug to be exhausted by the disappearance of an astringent taste. The exhaustion of alkaloidal drugs is best observed by directly testing a fraction of the percolate for the presence of alkaloids by means of Mayer's reagent. The color is but rarely a criterion of strength or exhaustion, for percolates may continue to pass through highly colored, and yet the drug may have long been devoid of activity; an exception to this is cochineal, whose virtues reside in its color only. *Hence, to carry on the process of percolation intelligently, we must understand the nature and constituents of the drug operated upon.*

After the drug has been exhausted, varying amounts of the menstruum are retained in the drug residue (marc). The recovery of this is quite important where larger quantities are operated upon. It is best then to throw the entire mass directly into a still, into the bottom of which live steam is passed and the distillate then condensed.

VARIOUS FORMS OF PERCOLATING APPARATUS.

For the use of the apothecary, in operating with smaller quantities of drugs, the glass percolator is the best, since by its use we are enabled to observe the various stages of the operation. It is also adapted to *all* kinds of drugs. Glass percolators of a larger size than five gallons are not safe, since, owing to their great size and weight, they are liable to crack. The larger sizes should be supported upon frames covered with some soft material like rubber or cork. Next to glass, stoneware jars (Squibb's Siphon Percolator) are to be preferred. These may be used for quantities up to 200 pounds. Most manufacturers employ tinned copper percolators which permit the carrying on of operations involving 300 to 500 pounds of drugs.

Fig. 306 illustrates the Christ-Dieterich Percolator, which is made of tinned copper or earthenware, the sizes varying from one to 10 liter capacity. It is fed automatically from the flask, A,

through the tube, *e*, which may be made of any length desired so as to reach further down, should the percolator not be filled. The drug rests on the sieve bottoms, *a* and *b*, between which a layer of cotton may be laid. The flow of percolate is regulated by the stop-cock, *c*.

Fig. 307 illustrates a handsome percolator, constructed of glass, intended for operating with smaller amounts; these are also constructed of copper or enameled iron for larger quantities. The

Fig. 307.

Fig. 306.

Christ-Dieterich Percolator.

Percolator (Warmbrunn, Quilitz).

operation is essentially the same as that shown in the preceding illustration. The drug rests on a perforated porcelain disc, *b*. In actual practice, it is a very difficult matter to regulate the flow of the percolate, to any degree of uniformity, with a stopcock. Moreover, a stopcock is also very easily clogged by small particles of solid matter. Dr. Squibb has overcome this difficulty by using the siphon, as is shown in the following:—

Siphon Percolator.* This form of percolator was designed by Dr. Squibb, who claims for it the following merits: it combines maceration with percolation, enabling the operator to vary the amount of maceration easily during the process; it controls the rate of percolation perfectly, and renders the percolation uniform throughout the mass of substance, independent of the packing, hence it requires less skill and experience in packing to obtain a given success in result; it is economical on the material, and as nearly automatic and self-controlling as a piece of apparatus can well be, and therefore requires the least time and attention; it successfully exhausts substances in coarse powder better than the usual forms, hence it is better adapted for the use of the apothecary than the usual form, which requires a great deal of care and skilful manipulation.

FIG. 308.

Siphon Percolator.

Fig. 308 illustrates one form of this percolator best adapted for handling smaller quantities of the drug. The description given by Dr. Squibb in his paper before the American Pharmaceutical Association in 1872 is as follows:—

"The percolator, *a*, is of the form of the modern glass percolator, somewhat funnel-shaped, to allow substances to swell without becoming impacted, having no outlet at the bottom; the delivery tube being converted into a solid stem, and this terminating in an ordinary circular foot upon which the percolator is supported. The total height is 15½ to 16 inches, or about 40 centimeters, of which about 4 inches, or 10 centimeters, is foot and stem. The interior dimensions, to accommodate conveniently an official portion of 16 troy ounces of any powder, however light, and a good portion of menstruum above it, is 11½ inches, or 26 centimeters, deep, 5½ inches, or 14 centimeters, across the top, and 2 inches, or 5 centimeters, across the bottom, which should be flat, as shown in the drawing, and not cup-shaped, as the glass blowers are apt to leave it. A rim of glass is made upon the upper edge or lip to thicken it, and this lip is ground off so that the cover may fit accurately to prevent loss by evaporation.

"A disc of flannel or blanket, *b*, is cut so as to lie flat upon the bottom, which it entirely covers.

"Another disc of the same material, but a little larger, *c*, is made with a crucial incision in the center, so that it may be stretched over the end of the well tube.

"The central or well tube, *e*, is a simple piece of glass tube about 12 inches, or 30 centimeters, long by ½ to ¾ of an inch, or 1¼ to 2 centimeters, internal diameter. Over one end of this well-tube the upper disc of blanket is stretched, the end being pushed through the crucial cut so that the disc fits tightly on the tube, the four corners made by the crucial cut being reflected up against the sides of the tube.

* Sometimes called "Well-tube Percolator."

The disc is then slipped up to the other end of the well-tube, and is tied firmly on to the tube by small twine or thread wrapped around the corners of the disc where they are reflected up against the tube.

"A disc of filtering-paper, *d*, larger than the blanket, with a crucial cut in the center, is cut in toward the center around the edge so as to lie flat against the sides of the percolator where reflected up against them. This disc of paper is pushed down upon the upper blanket.

"If now a piece of paper be twisted around the upper end of the well tube, or a cork be temporarily stuck into it, the percolator is ready to receive its charge, which is packed in around the well-tube and upon the discs of paper and blanket so as to occupy the lower part of the body of the percolator, *h*.

"When the charge, having been properly moistened, rubbed, and sifted, is packed in around the well-tube, its surface is covered by a disc of muslin, *i*, of proper size, and this is held in place conveniently by some fragments of broken glass thrown in upon it. The percolator is then ready to receive the menstruum or weak percolate, and enough of this should be poured on at once to fully saturate the entire substance. The liquid then passes down like a piston, forcing the interstitial air out through the blankets into the well tube, whence it escapes freely.

"A snugly fitting cover, *j*, is the next requisite, to prevent unnecessary loss by evaporation. This is very conveniently made from sheet rubber, $\frac{1}{4}$ to $\frac{3}{8}$ inch, or $\frac{1}{2}$ to 1 centimeter, in thickness. A disc 7 inches, or 18 centimeters, in diameter has a hole cut in its center, by means of a wet cork borer, of such a size as to slip easily over the upper end of the well-tube. As it is troublesome to raise this cover every time the percolator is to be supplied with liquid, it may be, by means of a sharp knife, kept wet and directed by a ruler, cut nearly through, so that the uncut part of the thickness serves at once as a hinge and a spring, and permits a part, say one-third, of the cover to be raised without raising the remainder, as shown in the drawing.

"The percolator is now charged and in readiness to start the percolation. The menstruum will have passed down through the whole of the substance and will have arisen in the well-tube to nearly the same level as that of the liquid on top, and the entire mass will be saturated and in maceration; and the whole arrangement will represent a well dug in the soil of the wet substance. Now, to pump out that well at a rate no faster, but just as fast, as the saturated liquid passes into it through the porous strata at the bottom, is the final step of the process.

"This is most conveniently done by a siphon, *f*, which can be easily raised or lowered through the whole depth of the well. This siphon is made of glass tubing of about $\frac{1}{8}$ inch, or 3 millimeters, bore, bent twice at right angles, the two legs about $12\frac{1}{2}$ inches, or 31 centimeters, long, and $4\frac{1}{2}$ inches, or 11 centimeters, apart. The outer leg is a little longer than the inner one, and turned up upon itself for about $\frac{3}{4}$ inch, or 2 centimeters, as shown in the drawing. The legs should have only such a difference in length that the inner one should reach the bottom of the well when required, and when measured upon the outer one should reach to about half the length of the short turned-up portion. This arrangement prevents the entrance of air into the siphon, and thus prevents it from emptying itself, for when the liquid is drawn over by the siphon until the surface falls to the level of the turned-up point at the outer end, the columns of liquid will be of equal length and will counterbalance each other, and the flow will cease. But as soon as the outer level is raised by the addition of fresh liquid the flow will recommence at a rate proportionate to the difference of level. It is this automatic and constant self-regulating action of the siphon that enables the design of this percolator to be carried out in practice, and the facility with which the siphon is raised or lowered in the well gives the operator perfect control over the process.

"One or more short pieces of concentric india-rubber tubing, *g*, stretched tightly upon the inner end of the siphon, but fitting loosely in the well-tube, serve to guide the lower end of the siphon and keep it near the center of the well-tube.

"Other short pieces of rubber tubing of different sizes, one over the other, so as to form a soft stopper for the upper end of the well-tube, as shown at *k*, completes the guide by which the siphon is kept in proper position. The inner piece of tubing composing this stopper should be large enough to move freely and easily upon the siphon, while the outer piece should fit the well-tube snugly. Then when the siphon is raised to the desired position and this stopper pressed into the well-tube lightly, it pinches the siphon lightly, but sufficiently to hold it in the desired position and to enable the operator to change the position at will without deranging the apparatus

"A receiving flask or bottle, *l*, marked in the neck or at some convenient place to the measure of a pint, and some wooden blocks to support this receiver at various heights, completes the apparatus. When the mouth of the receiver is left upon the same level as the liquid in the percolator, of course the receiver can never run over, and this is the position to which the receiver should be blocked up when left for the night or for a longer time. The liquid will then accumulate in the receiver more and more slowly, immersing the end of the siphon, until the level approaches or reaches that of the liquid in the percolator, and will then remain at rest, but in readiness to start at any moment when the levels may be disturbed either by a fresh supply of liquid to the percolator or by lowering the receiver.

Fig. 309.

Siphon Percolator.

"In order to save space at the top of the drawing, the siphon is represented at nearly its lowest position, a position rarely required except at the end of a percolation when the very last portions of liquid are to be drained off. The position of the siphon is to be regulated by the rate of flow, and the position regulates the rate of flow. Therefore this rate must be arbitrarily adopted in view of the fact that the slower the rate the more effective is the percolation. The rate, upon this scale, should never exceed twenty to thirty drops per minute, or two to four fluidounces per hour.

"When the percolation is ready to be started, that is, after the substance is fully

saturated and a stratum of liquid lies above it unabsorbed, the liquid in the well will be found to have arisen nearly to the level of the liquid outside the well-tube. It never rises quite as high within, because this liquid is more dense than the outer liquid, and the column is therefore heavier.

"The siphon is then introduced and fixed by the stopper in such a position that the inner end is immersed in the liquid of the well to the extent of two or three inches. The siphon is now ready to be started. The starting is perhaps best done by means of a short piece of small rubber tubing on the end of a longer piece of glass tubing. The rubber tubing should fit snugly over the turned-up end of the siphon, and then by suction with the mouth through the glass tube the siphon is carefully filled from the well. Before slipping off the rubber end of the suction-tube from the end of the siphon, the receiver is to be put in place, so that the first drops from the siphon, as well as those which may have passed into the suction-tube, will fall into the receiver. The rate of flow may be very rapid for a few moments, but will soon diminish to uniformity as the levels become adjusted to the uniformity of the rate of flow. If this rate be more than twenty drops per minute the siphon is to be raised carefully, and a little at a time, so as not to expose the end above the liquid in the well, and thus allow the air to enter the siphon, until the required rate is attained. As the rate varies with the varying density of the percolate during the process the siphon is to be from time to time raised or lowered so as to restore it to the desired standard. When exhaustion is practically effected, the siphon is pushed down to the bottom of the well and all the liquid drained off. The exhausted substance may, by care, be then removed, and replaced by a fresh portion, without disturbing the well tube or discs of blanket and paper, which is a considerable advantage in repercolation, where the same drug is used in successive portions.

"The difference in drugs and their menstrua, and difference in the fineness of the powders used, requires a difference in the position of the siphon for every percolation in order to attain a uniform rate. In a few drugs in fine powder, and packed pretty firmly, the siphon requires to be kept down at the bottom of the well, particularly in repercolations when dense weak percolates are used on top, from the very first start, and even then the rate will often be far below the standard of twenty drops per minute. But such percolations are always very successful, and very economical except in the time required. When the powder is very coarse and the menstruum thin and light, the siphon is kept very high."

A larger form, is that illustrated in Fig. 309, which represents a stoneware pot of about 2 gallons (about 7.6 liters) capacity, 10 inches (24 Cm.) high, 10 inches across the top, by about 6 inches (14.4 Cm.) across the bottom, inside, holding about 5 to 6 pounds (2 to 3 kilos). These pots should be well glazed inside; they are made of all sizes, adapted to quantities up to 200 or 300 pounds. The manner of filling and the subsequent operations are the same as those mentioned under the preceding.

Pressure Percolation.—For the purpose of hastening the operation of percolation, two methods have been proposed: one by creating a vacuum below the drug in the percolator, thereby increasing the pressure above, and the other, by means of hydrostatic pressure caused by a column of menstruum supplied from a reservoir at a height of from 5 to 10 feet. This latter is the embodiment of the principle of the old Real's pressure apparatus (page 191). There are a number of different forms of this pressure percolator, among which are those of Stearns, Rosenwasser, Suits, Berry, Anderson, and Lentz. They all differ slightly in various points of construction, but the principle of all is the same, namely, the rapid percolation of drugs by forcing the menstruum at a greater rate of speed than ordinarily attained.

These instruments may be used with advantage in some cases, for instance, for squills or calumba, which swell considerably, and allow the percolate to pass only slowly. However, the operation should not be hurried, otherwise the particles of the drug are liable to be simply washed with the menstruum. In order that percolation may be successful, time must be given to the menstruum to penetrate the cells of the drug, and to take up the soluble matter, otherwise a satisfactory exhaustion cannot be ex-

Fig. 310.

Fig. 311.

Lentz's Pressure Percolator.

pected. The apparatus devised by Lentz (Figs. 310, 311) will illustrate the application of the principle. The percolator, *h*, is made of tinned copper, provided below with a light cover, having a stopcock, *m*, as outlet for the percolate; this cover is made air-tight by a rubber ring being laid between the flat edges, held in position by means of clamps. The powdered drug rests upon the perforated bottom, *g*, being held in position by the adjustable porous diaphragm, *i*, which is pressed down on the surface of the powder. The menstruum is supplied from the reservoir, *b*, which can be

raised to any height desired. The Suits Pressure Percolator is made of glass, so that the entire operation can be seen; this is also provided with a rubber bulb air-pump for producing air pressure when hydrostatic pressure is no longer available.

VACUUM PERCOLATION.—This method of percolation was proposed by Duffield in 1869. This consists in introducing the powdered moistened drug into a tight cylinder and exhausting as much as possible of the air by means of a pump. Thus by the removal of the air enclosed in the interstices of the drug, the menstruum is enabled to penetrate the drug more rapidly and thoroughly, thereby facilitating maceration and subsequent exhaustion. An apparatus (devised by W. M. Thomson), based on

FIG. 312.

Percolator with Air Pump.

this principle, is shown in Fig. 312. The following description is that given by R. F. Fairthorne.*

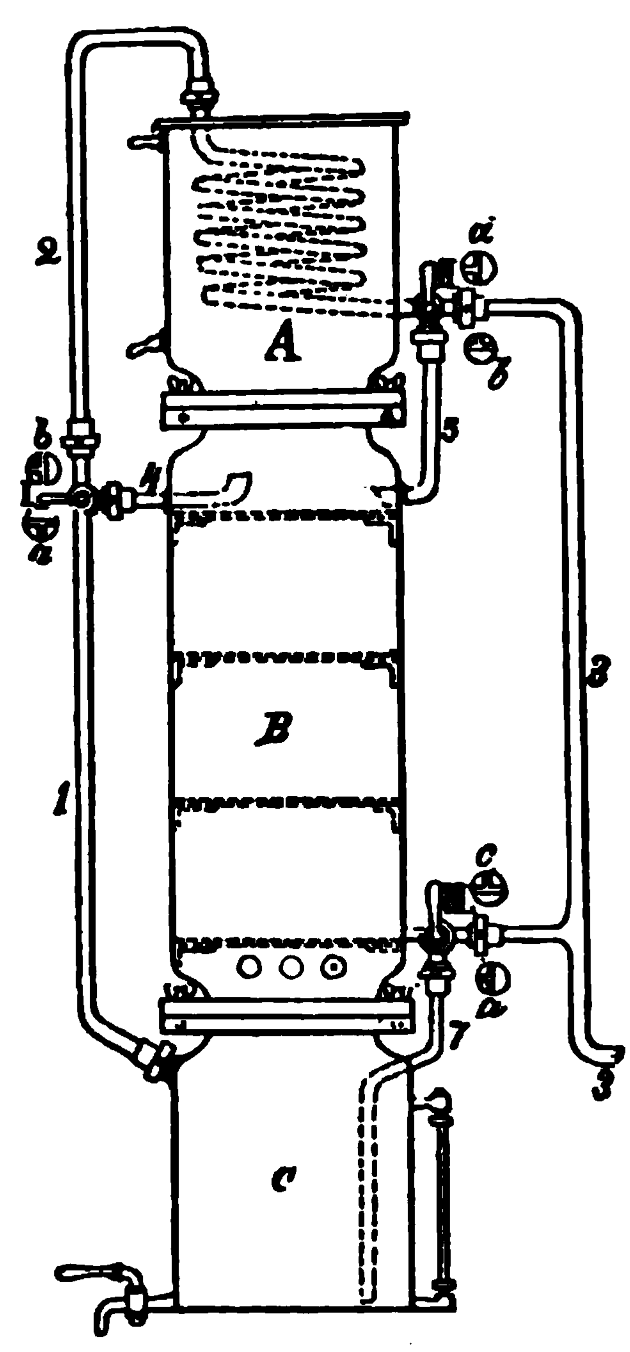
"The shape of the percolator differs somewhat from the usual form, being to some extent egg-shaped, whereby free percolation is insured. The cover (B), which is hemispherical in shape, is fastened upon the body (A) by means of clamps, with india-rubber rings between to render the joint air-tight. The drug to be operated on, having been sufficiently moistened with the menstruum and packed, is next exhausted of as much air as possible by a vacuum being produced through the upper part of the vessel by means of

* *Amer. Jour. Phar.*, 1882, p. 237.

an air-pump (G), which is connected with it by means of the tube (F). The stop-cock (H) is next closed and (M) opened, connecting with the tube (E), the end of which dips into the liquid to be employed as menstruum, and thereby a sufficient quantity of it is allowed to be drawn into the displacer to cover the drug. The stop-cock (M) is then closed and the materials allowed to macerate for several days. To start the percolation the receiver (C) is exhausted of air and the tap (I) having been opened the saturated fluid will begin to drop, and continue to do so so long as the force of the vacuum in the receiver is equal or greater than that in the upper vessel. When it begins to stop, air is admitted above the drug, which is drawn through the material, carrying with it much of the remaining liquid. To finish the operation air is forced into the percolator by means of the pump."

REPERCOLATION.—According to Dr. Squibb, it consists in the successive application of the same percolating menstruum to fresh portions of the substance to be percolated. Its object is to prepare fluid extracts without the use of heat, also effecting a saving in alcoholic menstruum, in which the weaker unsaturated percolates from one portion of the drug are employed in exhausting fresh portions of the drug. For application of the process see under Fluid Extracts.

FIG. 313.



Lewin's Extraction Apparatus.

HOT EXTRACTION OR CONTINUOUS PERCOLATION.—For the exhaustion of a drug by means of a hot menstruum various forms of apparatus have been offered; very few, however, are adapted for the use of the apothecary for extracting from one to five pounds of drug. One of the most convenient forms for pharmaceutical operations is Lewin's Extraction Apparatus (Fig. 313). This is adapted for (1) *continuous extraction with hot menstrua*, (2) *continuous extraction with cooled menstrua*, (3) *recovery of the menstrua from the finished extract by direct distillation.* The apparatus is composed of three easily separable principal parts: C, the tinned copper still, B, the copper percolator, which is provided with three movable sieve bottoms for the reception of the substance to be extracted. A is the condenser.

For the Continuous Extraction with Hot Solvents, the vapors pass from the still, *C*, in the tube *1*, and enter through the tri-faucet *I*, when in position *a*, through tube

A, into the percolator, *B*, penetrate the substance to be extracted, and condense. The percolate passes into the receiver and from this flows through the tri-faucet *III*, in its position *a*, through the tube *7*, again into the still, to repeat this course as long as may be necessary or desirable. To prevent pressure in the apparatus, the tube *2*, is removed during this operation, and the tri faucet *II* is placed in position *a*. This admits the vapor into the cooling worm, *A*, which thus forms a safety valve.

For the Continuous Extraction with Cooled Solvents, the vapors pass from the still, *C*, into the tube *1*, and enter through the tri-faucet *I*, in its position *b*, through tube *2*, into the cooling worm, *A*, from this as liquid through the tri-faucet *II*, in its position *a*, into the percolator, and so through the substance to be extracted into the still as before.

FIG. 314.

Currier's Extraction Apparatus.

For the Recovery of the Solvent from the Extract by Direct Distillation, the vapors pass from the still, *C*, through tube *1*, through the tri-faucet *I*, in its position *b*, through tube *2*, into the cooler, *A*, through the tri-faucet *II*, in its position *b*, into the exit tube *3*, which latter may be lengthened at pleasure.

Portions of the percolate may be removed from the receiver at pleasure through the tri-faucet *III*, in its position *c*, by the tubes *2* and *3*. All of the tubes are connected or disconnected by good screw-joints.

Fig. 314 illustrates the extraction apparatus of C. O. Currier, which recommends itself for simplicity and cheapness.

It consists of a glass flask, O; glass percolator, K; and a condenser, R. The condenser is the only part that will have to be made; the other parts of the apparatus are to be found in almost every laboratory. The condenser is a modification of the Liebig condenser, consisting of a number of tubes instead of one, thereby increasing the condensing surface and distributing the condensed liquid evenly over the surface of the drug. The condenser is made in the following manner: A tube of tinned copper is made one inch less in diameter than the top of the percolator to be used, and about two or three times as long as its diameter. A cap of tinned copper (tinned side out) is fitted to each end of the tube. The tube is traversed by tin tubes (made by cutting off block-tin pipe to the proper length) that project three fourths of an inch below the lower cap, and are cut off obliquely to facilitate the dropping of the condensed liquid. One of the tubes, A, is in the center, and passes through the upper cap about six inches, to which a bent safety tube may be attached to prevent undue pressure to the apparatus. The other tubes G, H, C, D, are closed at the top and pass into the condensing tube to within one-half inch of the top, and are arranged in a circle around the central one. Their number can be increased or diminished according to the size of the apparatus, four or five being sufficient for a pint percolator. Holes for these tubes should be made through the lower cap just the size of the tubes, and the tubes soldered to the cap 2, on the inside before the cap is soldered to the condensing tube. A small brass tube, F, is inserted in the condenser near the bottom and one near the top, B, for the entrance of cold water and exit of warm water. A cork is chosen that will fit tightly into the top of the percolator, and a circular piece cut out of it, just the size of the condenser, R, and is put upon the lower part of it at E. The cork can be kept in place and prevented from slipping up the tube when pressing into the percolator by soldering a collar of tin to the condenser at a distance from the bottom equal to the thickness of the cork.

The apparatus is used in the following manner: A cork, N, with longitudinal

channels cut in its surface, is inserted in the neck of the percolator, K; through the center of the cork, a glass tube, L, is passed to within two inches of the top of the percolator. The tube should be bent over at the top, to prevent its being clogged up by the drug while packing it into the percolator. A little cotton is placed in the percolator and pressed down upon the cork, and the drug packed in the usual manner. The percolator is then fitted into the neck of the flask, O, by means of a perforated cork, M, the liquid to be used as a menstruum having been previously put in the flask. The condenser is then connected firmly with the top of the percolator. The joints are luted with ground flax-seed mixed into a stiff paste with water. The tube F is connected with a supply of cold water by means of a rubber pipe, and the tube B with a sink or waste-pipe. The apparatus thus put together is placed in a water-bath and the heat applied. The flask should be immersed in the water to the point marked S on the neck. After the drug is exhausted the percolator is removed from the flask and the flask is connected by means of a bent tube with a Liebig's condenser, and the liquid recovered.

For apparatus adapted for the extraction of smaller amounts of substances, see Oleoresin, page 290.

CHAPTER XXV.

EXPRESSION.

Expression is forcible straining. The separation of fluid from solid matter is effected in small operations by hand, the straining cloth being used (Fig. 256). On the larger scale, as in the removal of the last portions of fluid from drug residues, it is accomplished by means of presses or the centrifugal machine. Expression is a necessary part of the process of Maceration; it is also required in the operations of Percolation, for the removal of menstruum adhering to the dregs or "marc." In some instances, the mass is thrown directly into the press or centrifugal machine; in others, it is first enveloped in a strainer of press cloth, before being subjected to pressure.

For the purpose of enclosing the material which is to be subjected to pressure, we employ the *press-cloth* or bag; this must be made of a material sufficiently strong to withstand great pressure without rupture. For this purpose strong canvas may be used, or, better, the so-called press-cloth, which is specially made for this purpose. In conducting the process of expression, pressure should be applied very slowly, otherwise, should the substance contain much fluid, the cloth will be ruptured. After the greater part of the liquid has been pressed out and the pulp has become firm, the pressure may be gradually increased to the full power of the press. The compression should be carried on in stages, the press being allowed to rest a few moments after each increase of pressure, thus allowing a new portion of the fluid an opportunity to drain off, and at the same time affording the particles of the mass an opportunity to assume their new positions in closer contact. Each subsequent increase of pressure will require a comparatively smaller effort.

Screw Presses.—Fig. 315 illustrates the more common form, which consists of a vertical screw operated by a lever, the lower end of this screw fitting into a cavity in the top of the plunger, which is free to move about in the limited space of the cylinder. The body of the press consists of an outer metallic casing, which serves to receive the fluid when forced through the perforated sides of the inner cylinder. All the parts of the press, which come in contact with the drug or fluid, should be well tinned, to prevent rusting, also to avoid discoloration or injury to the product should it contain tannin-like principles or acids. The drug to be expressed should be first carefully enveloped in a moistened press-cloth (if straining has not been performed), care being taken to fold over the corners, so as to form a square, compact pack. For

this purpose, the cloth should be sufficiently large, so that there may be no danger of the drug being forced out. The pack, or

FIG. 315.

Tincture Press.

FIG. 316.

Differential-Arm Screw Press.

the loose drug, if it should require no press-cloth, should be placed uniformly in the cylinder, so that it may receive equal pressure on all sides.

Fig. 316 illustrates the *Differential-arm Screw Press*, in which the arm is moved back and forward in a half-circle, whereby the screw is forced downward. This is the most powerful hand screw press made.

FIG. 317.

Witt's Pharmaceutical Press.

Fig. 317 illustrates an elegant screw press designed by Prof. Witt, which is specially adapted for expressing strongly acid or alkaline liquids from masses. It recommends itself for all purposes, since the press-block and all the parts with which the fluid comes in contact are made of the strongest porcelain.

A very convenient form of press, which can be operated without the use of the press cloth, is the *Enterprise Screw Press* (Fig. 318). This consists of a horizontal conical cylinder having a hopper on the upper side of the larger end. A tapering screw fits closely to the inner surface of the case, on the under side of which

FIG. 318.

Enterprise Screw Press.

is a narrow channel, into which slides a perforated brass strip, which permits the escape of the expressed fluid below. The substance is fed into the hopper, where, by means of the revolving screw, it is carried forward and forced into a smaller and smaller space, undergoing thereby a gradually increased pressure, being finally discharged, in a dry condition, through a small opening in the end of the cylinder. This opening may be regulated by means of a thumb-screw, which controls the amount of pressure to which the material is subjected. This screw press is employed largely for the recovery of juices from berries and fruits.

FIG. 319.

Knee-Lever Press.

The Wedge and Double Screw Presses are somewhat antiquated, and are not now employed in Pharmacy, since, owing to their construction, they are cumbersome and entail considerable loss of fluid. For pressing larger amounts, a very good form is the *Knee-lever Press* (Fig. 319), which consists of a horizontal screw, operated by means of either a spoked wheel or ratchet bar, causing the knee to be raised or lowered.

HYDROSTATIC, OR HYDRAULIC PRESS.—This is the most powerful of all the various presses employed. Its action depends on

the well-known law of equality of pressure, namely, that a "pressure exerted anywhere upon a mass of liquid, is transmitted undiminished in all directions, and acts with the same force on all equal surfaces, and in a direction at right angles to those surfaces."

There are various forms of presses depending on this principle, a more familiar form being illustrated in Fig. 320. It consists of a heavy steel cylinder, B, in which a cast-iron ram, P, works, supporting the plate on which the material to be pressed is placed. Four strong columns support and fix Q. By means of the force-pump, A, which works by means of a lever, M, water is driven into the cylinder through the tube, K, forcing the ram, P, upward. If the area of P is ten times greater than that of *p*, then a pressure of one hundred pounds transmitted through the lever, M, will exert an upward pressure of one thousand pounds on P.

Fig. 320.

Hydraulic Press.

The Centrifugal Machine (or Centrifuge).—As a means for the thorough and rapid separation of fluids from solids, the centrifugal machine forms an invaluable part of the outfit of many industries. It is used to separate the syrup (mother-liquor) from sugar crystals; also in the preparation of ammonia-soda in the Solvay process; in the removal of water from heavy precipitates; for removing the water retained by masses of cotton in the manufacture of absorbent cotton, etc., etc. The centrifugal machine is employed by the chemist in separating crystalline masses from the mother liquor; in the separation of fats from milk; the rapid separation of precipitates in analytical operations, etc. The centrifugal machine is also useful to the pharmacist for the separation of fruit-juices from their pulp, also, for the removal of fluid

matter from drug residues. While it does not remove the fluid as completely as a powerful press, yet it is exceedingly useful in

FIG. 321.

FIG. 322.

"Under-Driven Type." Centrifugal Machines. "Over-Driven Type."

many such operations. The machine consists essentially of a perforated cylindrical cage, fixed to a central shaft, and surrounded by a case. The inner cage revolving at a high rate of speed (up to several thousand revolutions per minute), anything contained in it is driven to the circumference, and if it be of a sufficiently fluid nature, it passes out through the perforations in the cage, and flies off tangentially. If we desire to free crystals from their mother-liquor, or to separate the adhering menstruum from a drug, we place them in the centrifugal machine, whereupon the mother-liquor, or fluid, escapes through the perforations in the cage, while the crystals, or drug, are left behind. Figs. 321 and 322 illustrate small machines, such as are intended for the laboratory. The one intended to be driven by hand belongs to the so-called "over-driven type," the other, to be operated by a water-motor, is of the "under-driven type." Fig. 323

FIG. 323.

Laboratory Centrifugal Machine.

illustrates an apparatus adapted for minor operations in the microscopical and pharmaceutical laboratory. As shown in the cut, the tubes containing the liquids are placed on the conical bed attached to the pivoted stem, and are held securely in place by leather straps and by depressing the cover lid, which is fastened by means of a slot. The apparatus is set in motion by means of a cord, preferably gut, which is wound around the axis, the action being, of course, to and fro, as in the case of the school-boy's buzzer. The apparatus must always be evenly and symmetrically ballasted, so as to insure even action.

Among the objects frequently subjected to centrifugal action, for the purpose of separating solids from the liquid, or for causing the heavier suspended solids to settle at the bottom, and the lighter suspended solids to collect at the top of the liquid, may be mentioned milk, cream, urine, sputum, fermenting liquids, etc.

PART II.

GALENICAL PHARMACY.

CLASSIFICATION OF PHARMACEUTICAL PREPARATIONS.

The various classes of preparations employed in pharmacy may be classed according to their physical and pharmaceutical characteristics:—

LIQUIDS.

I. SOLUTIONS.

AQUEOUS.

- Aquæ – (Injectiones Hypodermicæ).
- Liquores.
- Infusa.
- Decocta.
- Mucilagines.

ACETOUS.

- Aceta.

ALCOHOLIC, OR HYDROALCOHOLIC.

- Spiritus.
- Vina Medicata.
- Tincturæ.
- Tincturæ Herbarum Recentium.
- Succi.
- Extracta Fluida.

SACCHARINE.

- Syrupi.
- Mellita.
- Elixiria.

GLYCERIN.

- Glycerita.

OLEIC ACID.

- Oleata.

ETHEREAL.

- Oleoresinæ.
- Collodia.

II. MIXTURES.

- Linimenta.
- Misturæ.
- Emulsa (or Emulsiones).

SOLIDS.

I. FOR INTERNAL USE.

- Pulveres (P. Compositi).
- Triturationes.
- Oleosacchara (or Elæosacchara).
- Massæ.
- Confectiones.
- Trochisci.
- Pilulæ.
- Tablettæ.
- Extracta (also, Abstracta).
- Resinæ.

II. FOR EXTERNAL USE.

- Unguenta.
- Cerata.
- Emplastra.
- Chartæ.
- Suppositoria.

CHAPTER XXVI.

AQUEOUS SOLUTIONS.

AQUÆ MEDICATÆ.

Aquæ Destillatæ; Medicated or Distilled Waters. Eaux distillées, Hydrolats, Fr.; *Destillirte Wässer,* Germ.

Under the title of Aquæ is understood an aqueous solution in which distilled water is quantitatively the main constituent; the solutions being clear, free from undissolved solid matter, and, with few exceptions (Aqua Chlori, Picis, etc.), colorless.

As understood by the U. S. Pharmacopœia, Medicated Waters are simple solutions in which water has been impregnated with volatile substances. Foreign pharmacopœias recognize under this title aqueous solutions of certain non-volatile,* as well as volatile substances.

Many of the aromatic waters are employed as vehicles for the administration of remedies, others are employed internally as medicines, while a third class is used in chemical operations and the arts.

According to their method of preparation, they may be divided into three classes; those made by

1st. Direct Solution.
2d. Intermediate Solution.
3d. Distillation.

Direct Solution.—In those instances, where the substance is readily soluble in the given excess of cold water, solution is brought about by simple agitation, as in the official examples of Aqua Amygdalæ Amaræ, Aqua Chloroformi, and Aqua Creosoti. We may prepare many of the medicated waters by simple solution through agitation of the volatile oil with hot water (at about 50° C.), in a flask, allowing to cool, and then siphoning off the clear solution, or removing the undissolved oil from the surface of the solution by means of a wad of absorbent cotton. This method is based on the fact that volatile oils are more soluble in hot than in cold water; hence, by preparing a supersaturated solution, and then cooling it, a saturated solution will result. To this class belong those medicated waters, or more properly chemical solutions, which are obtained by dissolving gases in cold water. For their method of preparation see page 131. The official examples are Aqua Ammoniæ, Aqua Ammoniæ Fortior, Aqua Chlori, and Aqua Hydro-

* Aqua Calcis.

genii Dioxidi.* These solutions should be kept in glass-stoppered bottles in a cool and dark place.

INTERMEDIATE SOLUTION.—This method of preparation is by far the most satisfactory and convenient. It consists in saturating the distilled water by bringing it in contact with the volatile substance brought to a very finely subdivided condition by means of some intermediate agent. There are various ways of accomplishing this. Among the poorest was the method of the U. S. P. of 1880, in which the volatile oil or alcoholic solution of the volatile substance was dropped on absorbent cotton; this was directed to be picked, so as to distribute the material as much as possible; then the cotton was inserted in the neck of a funnel, distilled water poured over it, and the filtrate returned to the funnel until it was saturated. The main objections to this process were that the cotton not only permitted oily particles to pass through into the finished preparation, but also that the water was not as thoroughly saturated as that obtained by other methods; since it is impossible to bring about as thorough a state of subdivision of the volatile body by means of cotton as by the method of *trituration*. This latter method consists in thoroughly triturating the volatile substance, or a solution of it, with some insoluble, inert powder; then adding distilled water sufficient to form a smooth paste, after which the balance of the water is slowly added under trituration. This milky or turbid solution is poured upon a plain *wetted* filter, and the solution returned until it passes through clear.

Various insoluble powders have been proposed, such as magnesium carbonate, kaolin, talcum, calcium phosphate, silica, powdered pumice-stone, precipitated chalk, etc. The most satisfactory of these is the precipitated calcium phosphate, which, owing to its insolubility and freedom from soluble impurities, is adapted to all classes of these preparations.

Magnesium carbonate $4(MgCO_3).Mg(OH)_2.5H_2O)$ should *not* be employed for this purpose, since there is sufficient amount of magnesium hydroxide ($Mg(OH)_2$) present, which goes into solution, to interfere with its use for many purposes. Waters prepared with this will cause the precipitation of many alkaloids; react with some oils; blacken calomel when shaken with them; also cause the decomposition of many sensitive chemicals, such as silver nitrate, gold chloride, mercuric chloride etc. The official waters directed to be prepared by intermediate solution are: Aqua Anisi, Camphoræ, Cinnamomi, Fœniculi, Menthæ Piperitæ, and Menthæ Viridis. The medicated waters belonging to this class should be prepared from the very best grades of the volatile oil obtainable. Old resinified oils are worthless. These waters may also be prepared by the following method of distillation:

DISTILLATION.—This method, though applicable only to those

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* Although H_2O_2 is not a gas in the usual sense of the term, the solution is classed here for sake of convenience.

waters whose aromatic properties are due to the presence of volatile oils, yields the finest quality of aromatic waters. In the preparation of these, a copper retort, tinned inside, is usually employed. The plant parts (leaves, seeds, crushed bark, etc.) are placed in a wire basket or cage,* which is suspended in the upper part of the body of the still, so that only the steam arising from the boiling water may pass upward through the material and over into the condenser. The drug should not come in contact with the boiling water nor touch the heated sides of the retort. It is much better to generate the steam in a separate vessel, and to blow it through the drug contained in the retort as shown in Fig. 153 (or 324). When prepared in this way, aromatic waters keep much longer and better, and are far more fragrant, because by the old method of boiling the plant parts and water together, the boiling

FIG. 324.

Apparatus for the Distillation of Volatile Oils. e. Boiler. r. Steam Pipe. s. Perforated bottom upon which plant parts rest. k. Condenser.

water took up all the extractive and mucilaginous matter of the drug, the presence of which not only injured the aroma of the distillate, but caused matters to be carried over which interfered with its keeping qualities. Before each operation, the still or retort should be thoroughly cleansed by blowing steam through it; if proper cleanliness is observed, the distilled water will be entirely free from foreign (retort) or empyreumatic odor, and will keep longer and better. This cleansing should take place immediately after each operation, otherwise, through resinification of particles of oil remaining in the retort, it will be found almost impossible to remove all odor.

Most pharmacopœias direct that the leaves, flowers, crushed or

* See Pharmaceutical Stills.

cut root or bark, etc., be macerated in water from 10 to 12 hours before distillation.

For each 100 parts of distillate required, it is best to employ from 10 to 20 parts of the dry seed or fruit, and 10 parts of the dry or from 30 to 50 parts of the fresh leaves or bark.* For strong aromatics, such as angelica, juniper berries, cascarilla, etc., 25 parts of the drug are sufficient.

Some prefer not to remove any volatile oil that may have separated in the distillate, but to transfer the entire liquid to a stock vessel and to set it aside after thorough agitation. The presence of the excess of oil tends to keep the water constantly saturated, and preserves it from fermenting. When the turbid water is to be dispensed, it should be passed through a wetted filter, which serves to retain the separated oil.

The U. S. P. recognizes two waters (concentrated) made by distillation, viz., Aqua Aurantii Florum Fortior, and Aqua Rosæ Fortior, which are known in commerce as "triple," and are used in preparing the weaker Aqua Aurantii Florum and Aqua Rosæ, by dilution with one volume of distilled water.

Only distilled water should be employed in preparing the official solutions, as well as in carrying out tests. Ordinary hydrant water often causes decomposition of such sensitive salts as silver nitrate, potassium permanganate, etc.; it is likewise irritating when used in preparing eye-washes. When we consider the low cost and the convenience with which pharmaceutical stills may be run, there is no excuse for any apothecary in substituting hydrant water for distilled.

It is not within the province of the pharmacist to prepare these concentrated (triple) fragrant waters; hence they are usually imported from southern France and Italy, or other countries where the orange tree and rose are specially cultivated. Among the best known distillers of fragrant waters are Bertrand Bros., Lautier, Chiris, and Tombarell Bros.

These concentrated waters retain their fragrance longer than the weaker, hence their use enables the pharmacist always to dispense a fragrant preparation.

These stronger waters are best preserved in cool, dark places, the stopper being loosely inserted to allow the access of a certain amount of air. Orange flower water should not be made from the oil (Neroli). Rose water can be made directly from the oil by the method of the German Pharmacopœia, in which from 3 to 5 drops of the oil are agitated with the liter of hot distilled water.

PRESERVATION.—Medicated waters rapidly deteriorate, hence they should not be made in larger quantities than are likely to be consumed before they spoil. Unless a layer of oil covers the surface of the water, they will soon deposit flocculent matter or

* The proportion depends upon the richness of the plant-part in volatile oil, these figures being general.

become ropy and lose their odor entirely. This is caused by a microscopic vegetable growth, which renders the preparation unsightly and unfit to dispense. In order to avoid this, the freshly prepared water should be put into clean glass-stoppered vials, of appropriate size, the bottles being entirely filled and well sealed to exclude air. In this condition, they may be preserved for an indefinite length of time.

Preservative agents, such as alcohol, glycerin, boric acid, etc., have been proposed, but their use is not advisable. The presence of small amounts of alcohol gives rise to acetic fermentation; larger amounts, as well as the presence of any other agents, interfere seriously with the various uses of these waters.

EXPLANATORY.

AQUA AMYGDALÆ AMARÆ (Bitter Almond Water; Bittermandelwasser, Germ.).—This contains 0.1 per cent. of the oil of bitter almond. The preparation is of variable strength, varying according to the source and quality of the oil of almond. When the artificial oil (benzaldehyde) is used, the product is free from hydrocyanic acid (HCN). If the true oil of bitter almond (containing from one to six per cent. HCN) is employed we find variable amounts present; should the oil contain six per cent. of absolute HCN, the water would contain about one drop of the official acid in each half ounce. It is employed in this country as a vehicle or flavoring agent.

AQUA AMYGDALARUM AMARARUM.—Under this title, we find a preparation official in various European pharmacopœias, which is prepared by distilling bitter almonds with water; this is far stronger than ours, being standardized to a definite percentage of hydrocyanic acid. It should be administered with great caution. In dispensing this preparation, care should be observed that it be of the exact strength required by the pharmacopœia which the physician employs. The strength in hydrocyanic acid as recognized in various pharmacopœias is as follows:—

Pharmacopœia.	*HCN in 1000 Parts.*
Austrian,	1
Belgian,	1
Danish, contains alcohol.	1.4
German, contains alcohol,	1
Netherlands.	1
Russian, contains alcohol,	1
Spanish,	0.86
Swedish, contains alcohol,	1.3–1.4
Swiss,	1

A substitute for this may be made by dissolving 6.46 grammes of chloral cyanhydrate in 1000 Cc. of distilled water. Each 6.46 grammes of this salt contains 1 gramme of HCN.

The above is used as a sedative in doses of from 10 to 15 drops.

Under the title of *Aqua Laurocerasi* (Cherry Laurel Water), a preparation of similar nature is official in several pharmacopœias. It is made by distilling a mixture of bruised fresh laurel leaves and water. This preparation is likewise standardized to a definite percentage of hydrocyanic acid.

Pharmacopœia.	*HCN in 1000 Parts.*
Belgian,	0.5
Netherlands,	0.839
British,	1
French,	0.5

The Spanish, German, Greek, and Swiss pharmacopœias substitute the above-mentioned bitter almond water for cherry laurel water.

The German Pharmacopœia prepares a diluted bitter almond water (Aqua Cerasorum or Kirschwasser), by mixing 1 part of the stronger with 19 parts of water. This preparation, containing 0.005 per cent. of hydrocyanic acid, should not be confounded with either of the above containing 0.1 per cent. of the acid.

AQUA CHLOROFORMI.—Chloroform is added in sufficient quantity to distilled water, so that, after agitation, it remains in slight excess; the supernatant saturated solution is decanted off as required. When exposed to sunlight, the chloroform readily undergoes decomposition, particularly so in the presence of water. Hence this preparation should be kept in a dark amber-colored bottle. It is employed as a solvent for many remedies, owing to its preservative properties; also, as an adjunct to anodyne mixtures.

AQUA CREOSOTI.—This preparation contains 1 per cent. of wood creosote. It is employed principally as a gargle, or lotion. In ordering creosote, care should be taken to specify "true wood creosote," or "beech-wood tar creosote," for under the term "commercial creosote" carbolic acid is usually understood.

Under the class of Aquæ, solutions of gases are included, viz.:—

AQUA AMMONIÆ.—(Specific gravity 0.960, containing 10 per cent. by weight of gaseous ammonia (NH_3).) It is known among the continental pharmacopœias under the title of "Liquor Ammoniæ," being generally recognized to be of 10 per cent. strength (Fr. and Sp., 20 per cent.) This is commercially known as 16° Baumé; the so-called Aqua Ammoniæ f.f.f., being 20° B., or about 17 per cent. by weight of NH_3.

AQUA AMMONIÆ FORTIOR (sp. gr. 0.901, containing 28 per cent. by weight of gas), is only recognized by the U. S. and British Pharmacopœias, that of the latter, however, being of 32.5 per cent. strength.

For rules for dilution, see page 138.

Ammonia Water is incompatible with acids and most metallic

salts; it should be preserved in well stoppered bottles in a cool place. Its strength is ascertained by means of its specific gravity, or by titration with a standard acid solution.*

$2NH_3$	+	H_2SO_4	=	$(NH_4)_2SO_4$.
Ammonia.		Sulphuric Acid.		Ammonium Sulphate.
2 × 17 pts.	=	97.82 pts.		
17 pts.	=	48.91 pts.		
0.017 pt.	=	0.0489 pt.		

Since 1 Cc. of decinormal sulphuric acid solution (containing 0.0489 Gm. H_2SO_4) neutralizes 0.017 Gm. of ammonia gas (NH_3), 20 Cc. of the acid solution will be equivalent to $20 \times 0.017 = 0.34$ Gm. of NH_3. If 3.4 Gm. of Aqua Ammonia were taken for the assay, it would then, according to the above, contain 10 per cent. of ammonia gas.

Aqua Chlori.—A clear, greenish-yellow liquid, containing at least 0.4 per cent. of chlorine gas, U. S. P. This preparation is official in all pharmacopœias, and contains from 0.3 to 0.6 per cent. of chlorine gas. It should be freshly prepared when required for use, since it rapidly undergoes decomposition; thus, $2Cl + H_2O = 2HCl + O$. As a ready means of ascertaining whether this decomposition has begun, or not, the pharmacopœia directs agitation of the sample with mercury, which unites with the free chlorine, leaving any hydrochloric acid which may be present free to be detected by litmus paper.

Chlorine water is employed in medicine as an antiseptic. It is incompatible with alkalies, silver and lead salts, tannin, infusions, emulsions, and tinctures, and liberates iodine and bromine from their salts. When prescribed in mixtures it should be added last.

The chlorine strength of this preparation is ascertained indirectly by volumetric estimation.† This is based on the fact that chlorine displaces an equivalent amount of iodine from potassium iodide, according to the equation:—

$2KI$	+	$2Cl$	=	$2KCl$	+	$2I$.
Potassium Iodide.		Chlorine.		Potassium Chloride.		Iodine.
		2 × 35.3				2 × 126.5

The liberated iodine is held in solution by the excess of potassium iodide. In order to ascertain the amount of liberated iodine, decinormal solution of sodium hyposulphite is run into this dark-colored solution until it is decolorized, according to the following equation:—

$2I$	+	$2(Na_2S_2O_3 + 5H_2O)$	=	$Na_2S_4O_6$	+	$2NaI$	+	$10H_2O$.
Iodine.		Sodium Hyposulphite.		Sodium Tetrathionate.		Sodium Iodide.		Water.
2 × 126.5 pts.		2 × 247.6 pts.						
126.5 pts.		247.6 pts.						
0.01265 pt.		0.0247 pt.						

* See Volumetric Solutions, page 423. † Ibid, page 435.

Since 1 Cc. of decinormal solution of sodium hyposulphite containing 0.0247 Gm. of the salt, is equivalent to 0.01265 Gm. of iodine, therefore 20 Cc. of the hyposulphite solution will be equivalent to $20 \times 0.01265 = 0.253$ Gm. of iodine. Hence if one molecule of iodine is equivalent to one molecule of chlorine, 0.253 Gm. of iodine will be equivalent to x grammes of chlorine. That is,

$$\overset{I}{253} : \overset{Cl}{70.6} :: \overset{I}{0.253} : \overset{Cl}{x}.$$
$$x = 0.070 + \text{Gm. of Chlorine.}$$

If 17.7 Gm. of Aqua Chlori, after having been subjected to the above test, yield 0.070 Gm. of chlorine, it would then contain of the gas $17.7 : 0.07 :: 100 : x$; $x = 0.4$ per cent. (approximately).

AQUA HYDROGENII DIOXIDI.—This solution should contain 3 per cent. by weight of the pure Dioxide (H_2O_2), corresponding to about 10 volumes of available oxygen. The dioxide itself may be obtained in a very pure condition* by agitating barium peroxide with diluted hydrochloric acid and ether, the latter absorbing the H_2O_2; upon shaking the ethereal solution with distilled water, slightly acidulated, it gives up most of its hydrogen peroxide.

The great facility with which this solution gives up its oxygen renders it a powerful oxidizer. It bleaches organic colors, likewise hair; converts sulphides and sulphites into sulphates, ferrous into ferric compounds; liberates chlorine from hydrochloric acid, iodine from hydriodic acid, and iodide of iron; it reacts very slowly in a neutral solution of potassium iodide, thus differing from ozone and chlorine. It is stated that the addition of one part of H_2O_2 to 1000 parts of impure drinking water will, after a short time, effectually destroy any disease germs that may be present. It is employed in medicine as a powerful antiseptic, and deodorant. The presence of a little acid (even as little as one drop of HCl to the pint), is essential to prevent its too rapid decomposition.

The commercial solution scarcely ever contains over three per cent by weight of absolute peroxide, and the ten and fifteen volume solutions often fall short of the strength claimed for them; hence it behooves the apothecary to assay each lot which he may purchase.

The strength of this solution is sometimes indicated by *volume.* Thus a 20 volume solution is one which, when decomposed into water and oxygen, will yield 20 times its volume of oxygen. It does not matter, in this case, whether the whole of the liberated oxygen comes from the H_2O_2, or whether a part of this comes from the reagent added. If the H_2O_2 is decomposed by potassium permanganate, only one-half of the oxygen given off comes from the H_2O_2.

The strength of the solution is estimated by means of decinormal

* Cresiner, "Proceed. A. P. A.," 1892, p. 845.

solution of potassium permanganate * according to the following equation:—

$K_2Mn_2O_8$	+	$5H_2O_2$	+	$3H_2SO_4$	=	$5O_2$	+	$8H_2O$	+	K_2SO_4	+	$2MnSO_4$
Potassium Permanganate. 315.3		Hydrogen Peroxide. 169.6		Sulphuric Acid.		Oxygen.		Water.		Potassium Sulphate.		Manganese Sulphate.

The permanganate solution is added slowly, until the pink color no longer disappears. The presence of the sulphuric acid serves the purpose of dissolving the manganic hydroxide† as fast as formed, otherwise the brown oxide diffused through the liquid would render the end of the reaction difficult to distinguish. Now, according to the above equation, 1 mol. of $K_2Mn_2O_8$ (315.3 p.) corresponds to $5H_2O_2$ (169.6 p.); or 0.003153 Gm. of potassium permanganate (1 Cc. of the decinormal solution), corresponds to 0.001696 Gm. of absolute hydrogen peroxide. Where it is desirable to express the strength in *volumes of available oxygen*, we multiply the number of cubic centimeters of the solution of permanganate, decolorized by 1 Cc. of the solution, by 0.56. This latter factor is explained thus:—

Since one-half of the liberated oxygen is supplied by the potassium permanganate ($K_2Mn_2O_8$), one molecule of $\underset{315.3}{K_2Mn_2O_8}$ liberates $\underset{80}{\text{5 of oxygen}}$ from the hydrogen peroxide (H_2O_2); hence, 63 + Gm. of $K_2Mn_2O_8$ (one-fifth of 315.3) will liberate 16 Gm. of oxygen (one-fifth of 80), which at normal temperature measures 11,188 Cc. If 63 + Gm. of potassium permanganate liberate 11,188 Cc. of oxygen, 0.00315 Gm. of permanganate (1 Cc.) will liberate 0.56 Cc. of oxygen.

AQUÆ, U. S. P.

Medicated Waters Made by Direct Solution.

Title.	Constituents. ‡	Use.
Aqua Amygdalæ Amaræ,	0.1% Oil of Bitter Almond.	Vehicle.
Aqua Creosoti,	1% of Creosote.	Antiseptic.
" Chloroformi,	Saturated aqueous solution of Chloroform.	Antiseptic, Anodyne.

Medicated Waters Made by Dissolving Gases in Water.

Title.	Constituents.	Use.
Aqua Ammoniæ,	10% of Gaseous Ammonia, wt.	Stimulant, Caustic.
" Ammoniæ Fortior,	28% " " " "	" "
" Chlori,	0.4% " Chlorine, "	Antiseptic.
Aqua Hydrogenii Dioxidi,	3% " Hydrogen Dioxide, "	Antiseptic, Deodorant.

* See Decinormal Solution of Potassium Permanganate, page 439.

† The substance precipitated (from alkaline solution) is manganous hydroxide, which rapidly turns to brown manganic hydroxide.

‡ In this and subsequent tables % (per cent.) is employed merely as an expression of convenience. In the case of anise water and others of this class, it means 2 Cc. of the oil in 1000 Cc. of water. In the case of camphor water it means *8 Gm.* of Camphor in 1000 Cc. See "Percentage Solutions," page 137.

MEDICATED WATERS MADE BY INTERMEDIATE SOLUTION.

Title.	*Constituents.*	*Use.*
Aqua Anisi, ...	0.2% of Oil of Anise.	Vehicle.
" Camphoræ, . .	0.8% of Camphor,	Antispasmodic.
" Cinnamomi, . .	0.2% of Oil of Cinnamon.	Vehicle.
" Fœniculi, . . .	0.2% of Oil of Fennel.	"
" Menthæ Piperitæ,	0.2% of Oil of Peppermint.	"
" Menthæ Viridis, .	0.2% of Oil of Spearmint.	"

MEDICATED WATERS MADE BY DISTILLATION.

Title.	*Constituents.*	*Use.*
Aqua Aurantii Florum Fortior, ...	Triple Orange-flower Water.	
Aqua Aurantii Florum,	Equal parts of the above and distilled water.	Vehicle.
" Rosæ Fortior, . .	Triple Rose Water.	
" Rosæ, ...	Equal parts of the above and distilled water.	Vehicle.

INJECTIONES HYPODERMICÆ—(*Hypodermic Injections*).

When remedies are to be used hypodermically, it is absolutely necessary that these solutions be as *neutral* as possible and *sterilized*. As antiseptic vehicles, for the administration of these remedies, various solutions have been proposed, such as solutions of camphor, thymol, or corrosive sublimate, and chloroform water; however, when these solutions have been exposed to the air, they are not fit to be dispensed. When it is necessary to prepare such a solution, the test-tube in which it is prepared and the receiving vessel, should be first sterilized by rinsing them with boiling water, and then dried in an oven at a temperature of about 200° C. Only thoroughly boiled distilled water should be used as solvent. In Germany and Austria, these solutions are now often prepared and sealed in small, elongated glass pearls (sterilized at 200° C.) of 1 Cc. capacity. Thus sealed, these solutions may be preserved indefinitely and can be readily carried about. The sterilized hypodermic tablets, in which cane sugar made antiseptic with a small amount of boric acid forms the inert diluent, have become very popular, because of their convenience in use, and the accuracy of their dosage. These tablets should always be dispensed in their tubes and never handled with the fingers. The hypodermic dose of a remedy is ½ or less than the dose by the mouth.

LIQUORES—(*Liquors*).—SOLUTIONES—(*Solutions*).

Liquors are aqueous solutions of chemical substances. There are twenty-four of these official in the U. S. P., 1890.

EXPLANATORY.

Liquor Acidi Arsenosi (Liquor Arsenici Chloridi, U. S. P., 1880).—This is simply a solution of arsenous acid in hydrochloric acid and water, and not a definite compound. It is about twice as strong as Valangin's solution, which contains about 0.4 per cent., while the official product contains 1 per cent. of arsenous acid. Its properties are much the same as Fowler's solution, but its action is not reliable. Dose 0.12 to 0.6 Cc. (2 to 10 minims). For assay, see Liquor Potassii Arsenitis.

Liquor Ammonii Acetatis (Spirit of Mindererus).—If the pharmacopœial directions are strictly followed, a preparation of an acid reaction will be obtained. This is essentially necessary, otherwise, when it is added to solutions containing alkaloids or metallic salts, these would be likely to be precipitated from their combinations. Should such be the case, the addition of a little acetic acid, sufficient to clear up the solution, is necessary.

The reaction between the ammonium carbonate (a mixture of ammonium acid carbonate and carbamate) and acetic acid is as follows:—

$$\underset{\substack{\text{Ammonium Carbonate.}\\156.7}}{NH_4HCO_3.NH_4NH_2CO_2} + \underset{\substack{\text{Acetic Acid.}\\3\times 59.86}}{3CH_3COOH} = \underset{\substack{\text{Ammonium}\\\text{Acetate.}}}{3CH_3COONH_4} + \underset{\text{Water.}}{H_2O} + \underset{\substack{\text{Carbonic}\\\text{Acid Gas.}}}{2CO_2}$$

When freshly prepared, it contains free carbonic acid. The German and Swiss Pharmacopœias prepare this from ammonia water instead of from ammonium carbonate.

Exercise.—How much official ammonium carbonate will be required to neutralize 100 Cc. of diluted acetic acid, U. S. P.?—100 Cc. of the diluted acid weigh (100 × 1.008) 100.8 Gm.; 6 per cent. of this is absolute acid = 6.048 Gm., then:

$$\underset{\substack{\text{Acetic}\\\text{Acid.}}}{179.5} : \underset{\substack{\text{Ammon.}\\\text{Carb.}}}{156.7} :: \underset{\substack{\text{Acetic}\\\text{Acid.}}}{6.048} : \underset{\substack{\text{Ammon.}\\\text{Carb.}}}{x}$$

$$x = 5.27 +$$

hence, 5.27 + Gm. of official ammonium carbonate are required to neutralize 100 Cc. of official diluted acetic acid.

Liquor Arseni et Hydrargyri Iodidi (Donovan's Solution).—This is best made from the precipitated Iodide of Arsenic (Bamberger), as it is far more soluble than the commercial, made by

fusion. The solution should be kept in a dark place, as the action of light causes a partial separation of iodine with change to yellow color. When in this condition it should not be dispensed. This solution contains one per cent. of each of the iodides. It is incompatible with alkaline solutions, since they cause the precipitation of the mercury; it is also incompatible with solutions of silver salts, owing to the precipitation of the silver as insoluble iodide; also with weak alcoholic or aqueous solutions containing alkaloids, since it forms with them *insoluble* double salts.

LIQUOR CALCIS (Lime Water).—When water is added to calcium oxide (burnt lime), considerable heat is generated, with formation of calcium hydroxide $Ca(OH)_2$; this is soluble in 780 parts of cold water, but only in 1650 parts of boiling water. Each fluidounce of lime water would then contain about three-quarters of a grain of calcium hydroxide. Liquor Calcis should be prepared from a calcium oxide which is made from marble, a very pure form of calcium carbonate. When the calcium oxide is made from ordinary limestone, it will be contaminated with alkalies, which dissolve readily in water; hence the Pharmacopœia directs, that the slaked lime should be first treated with a small portion of water, which removes these impurities. Lime water should not be added to salts of alkaloids or of metals, nor to acid solutions. When added to calomel (1 drachm to the pint) it forms the so-called Black Wash (Lotio Nigra). When added to corrosive sublimate (one-half drachm to the pint), it forms the Yellow Wash (Lotio Flava, or Aqua Phagedænica). In the latter case, care should be taken that no free corrosive sublimate remains in the solution, which may arise from deficiency of strength of the lime water.

This solution should be kept in a well-stoppered bottle, away from access of the air, otherwise all of the calcium hydrate would soon be converted into and precipitated as carbonate.

LIQUOR FERRI ACETATIS.—This solution contains about 31 per cent. of anhydrous ferric acetate $(Fe_2(C_2H_3O_2)_6)$. It is prepared by dissolving ferric hydroxide in glacial acetic acid. The former is made by pouring a diluted solution of ferric sulphate, under brisk stirring, into ammonia water, whereby ferric hydroxide is precipitated. This precipitate is collected and well washed to remove adhering ammonium chloride.

$$\underset{\substack{\text{Ferric}\\\text{Sulphate.}\\2\times55.8\text{ Fe.}}}{Fe_2(SO_4)_3} + \underset{\substack{\text{Ammonia}\\\text{Water.}\\6\times17}}{6NH_3 + 6H_2O} = \underset{\substack{\text{Ferric}\\\text{Hydrate.}}}{Fe_2(OH)_6} + \underset{\substack{\text{Ammonium}\\\text{Chloride.}}}{3(NH_4)_2SO_4}$$

$$\underset{\substack{\text{Ferric Hydrate.}\\2\times55.8\text{ Fe.}}}{Fe_2(OH)_6} + \underset{\text{Acetic Acid.}}{6HC_2H_3O_2} = \underset{\substack{\text{Ferric Acetate.}\\464.9}}{Fe_2(C_2H_3O_2)_6} + \underset{\text{Water.}}{6H_2O}$$

The preparation, if made from acetic acid of proper strength, will keep readily; should a weaker acid be used, the preparation is liable to precipitate a basic ferric acetate (probably $Fe_2(OH)_4(C_2H_3O_2)_2$).

Assay.—The U. S. Pharmacopœia directs to add to 1.117 Gm. of the liquor, diluted with water, 2 Cc. of hydrochloric acid; this liberates the acetic acid with formation of ferric chloride; then on adding the potassium iodide, iodine is liberated, with reduction of the ferric to ferrous chloride and the formation of potassium chloride; thus:—

Fe_2Cl_6	+	2KI	=	$2FeCl_2$	+	2KCl	+	2I.
Ferric Chloride. 2 × 55.8 Fe.		Potassium Iodide.		Ferrous Chloride.		Potassium Chloride.		Iodine. 2 × 126.5

One atom of iron (55.8 pt.) is equivalent to one atom of iodine (126.5 pt.). The amount of iodine liberated is ascertained by means of decinormal solution of sodium hyposulphite,* which is added until the blue color (iodide of starch) disappears; thus,

I_2	+	$2(Na_2S_2O_3.5H_2O)$	=	2NaI	+	$Na_2S_4O_6$	+	$10H_2O$.
Iodine. 2 × 126.5		Sodium Hyposulphite. 2 × 247.6		Sodium Iodide.		Sodium Tetrathionate.		

One molecule of sodium hyposulphite (247.6 pt.) is equivalent to one atom of iodine (126.5 pt.).

1 molecule of ferric acetate = 1 molecule of ferric chloride; 1 molecule of ferric chloride, containing 2 atoms of iron, liberates 2 atoms of iodine, which correspond to 2 molecules of sodium hyposulphite.

1 atom Iron.		1 atom Iodine.		1 molecule Sodium Hyposulphite.
55.8 Gm.	=	126.5 Gm.	=	247.6 Gm.
0.00558 Gm.	=	0.01265 Gm.	=	0.02476 Gm.

Or

1 Cc. V. S. or 0.02476 Gm. of Sodium Hyposulphite = 0.00558 Gm. of iron.
15 Cc. of the Sodium Hyposulphite V. S. = 15 × 0.00558 = 0.0837 Gm. iron.

Since we took 1.117 Gm. of the liquor and 7.5 per cent. of this should be metallic iron, we find it to be 0.0837 + Gm.,† thus proving our answer.

Exercise.—What percentage of anhydrous ferric acetate is contained in the official Liquor Ferri Acetatis?

According to the equation, page 228, 111.7 parts of metallic iron (contained in $Fe_2(SO_4)_3$) are necessary to the formation of one molecule of ferric acetate ($Fe_2(C_2H_3O_2)_6$ = 464.9).

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* See Decinormal Solution of Sodium Hyposulphite, page 434.

† A plus (+) sign after a decimal fraction means that the last decimal is slightly *smaller* than the true value. A minus (—) sign placed in the same manner means that the last decimal is slightly *greater* than the true value.

1000 grammes of the solution of ferric sulphate taken contain 80 grammes of metallic iron (8 per cent. of 1000); then, as

2 Iron.*		Ferric Acetate.		Iron.		Ferric Acetate.
111.7	:	464.9	: :	80	:	x

x = 333 + Gm. ferric acetate.

Since the solution is made to weigh 1000 Gm., and contains 333 Gm. of the salt, $333 \div 10 = 33.3$ per cent. The solution should therefore contain 33.3 per cent. of the salt. This figure is not attained in actual practice.

LIQUOR FERRI CHLORIDI (Liquor Ferri Sesquichloridi Ph. Germ., Liquor Ferri Perchloridi Ph. Br.).—This solution should contain, according to the U. S. Pharmacopœia, 37.8 per cent. of anhydrous salt (Fe_2Cl_6).

The reaction consists first in the formation of ferrous chloride:—

(a) Fe	+	2HCl	=	$FeCl_2$	+	H_2
Iron. 55.8		Hydrochloric Acid. 2 × 36.3		Ferrous Chloride. 126.6		Hydrogen.

To convert this ferrous into ferric chloride, more hydrochloric acid is added to the solution, and this is poured into the necessary amount of nitric acid, which oxidizes the hydrogen of the hydrochloric acid to water, undergoing itself reduction to nitrogen dioxide (N_2O_2 or NO), which with the oxygen of the air forms nitrogen tetroxide (N_2O_4 or NO_2), and is evolved as such, while the chlorine liberated from the hydrochloric acid unites with the ferrous to form ferric chloride, thus:—

(b) $6FeCl_2$	+	6HCl	+	$2HNO_3$	=	$3Fe_2Cl_6$	+	$4H_2O$	+	2NO
Ferrous Chloride. 6 × 126.6		Hydrochloric Acid. 6 × 36.3		Nitric Acid. 2 × 62.9		Ferric Chloride. 3 × 324		Water.		Nitrogen Dioxide.

The solution is then further heated, to remove any excess of nitric acid or nitric oxide, then afterward tested for the presence of these by the addition of a crystal of ferrous sulphate to a few drops of the solution diluted with a little water, mixed with an equal volume of sulphuric acid, and allowed to cool. A dark-brownish zone ($FeSO_4.NO$) forms around the crystal if any nitric acid be present. Should such be the case, it is necessary to heat the solution further. Care should be taken not to allow the liquid to become too concentrated, nor to employ too high a degree of heat (it should not boil), nor to heat too long, otherwise a portion of the iron will be converted into oxychloride, which separates on the addition of alcohol. The Pharmacopœia directs that the solution be free from ferrous chloride. This is detected by adding a few drops of potassium ferricyanide T. S. to about the same quantity of the solution well diluted with water, when no blue coloration or precipitate should occur:—

$3FeCl_2$	+	$2(K_3(FeCy_6))$	=	$Fe_3(FeCy_6)_2$	+	6KCl
Ferrous Chloride.		Potassium Ferricyanide.		Ferrous Ferricyanide, Turnbull's blue.		Potassium Chloride.

* For the sake of convenience and brevity, the various atomic and molecular weights are expressed only to the first decimal point; in some instances the nearest whole number is selected.

Assay.—The process is identical with that given under Liquor Ferri Acetatis. One Cc. of decinormal sodium hyposulphite V. S. (0.02476 Gm. of the salt) is equivalent to 0.00558 Gm. of iron, hence 26 Cc. $= 26 \times 0.00558 = 0.14508$ Gm. of iron. Since, according to the Pharmacopœia, the solution should contain 13 per cent. of metallic iron, and 1.12 Gm. were taken for assay, then this should contain 0.145 + Gm. of iron (13 per cent. of 1.12). Hence, according to the above, the solution is of proper strength.

Exercise.—How much anhydrous ferric chloride can be made from 150 Gm. of pure* iron wire?

According to the equation *a* (page 230), 55.8 parts of iron will yield 126.6 parts of ferrous chloride; hence 150 Gm. of iron will yield 340 + Gm. of ferrous chloride:—

$$\begin{array}{ccccccc} Fe & & FeCl_2 & & Fe & & FeCl_2 \\ 55.8 & : & 126.6 & :: & 150 & : & x \end{array}$$
$$x = 340 + \text{ grammes of ferrous chloride.}$$

According to the equation *b*, 759.6 parts of anhydrous ferrous chloride, when oxidized, yield 972 parts of anhydrous ferric chloride; 340 + Gm. of ferrous will yield 435.4 Gm. of ferric chloride:—

$$\begin{array}{ccccccc} 6FeCl_2 & & 3Fe_2Cl_6 & & FeCl_2 & & Fe_2Cl_6 \\ 759.6 & : & 972 & :: & 340 & : & x \end{array}$$
$$x = 435 +.$$

Therefore, 435 + Gm. of ferric chloride can be obtained from 150 Gm. of iron if it be absolutely pure.

Exercise.—How much iron is capable of being taken up by 540 Gm. of hydrochloric acid (U. S. P.) to form ferrous chloride.

According to the equation *a* (page 230), 72.6 parts of absolute hydrochloric acid are able to combine with 55.8 parts of metallic iron. If the sample of acid be of U. S. Pharmacopœia strength, it will contain 172.2 + Gm. of absolute acid (31.9 per cent. of 540).

$$\begin{array}{ccccccc} HCl & & Fe & & HCl & & Fe \\ 72.6 & : & 55.8 & :: & 172.2 & :: & x \end{array}$$
$$x = 132.3 \text{ Gm. Fe.}$$

Therefore, 540 Gm. of hydrochloric acid (U. S. P.) will combine with 132.3 Gm. of pure iron to form $FeCl_2$.

All Ferric Solutions are Incompatible with the Alkali Bromides or Iodides, since Free Bromine or Iodine is Liberated.

LIQUOR FERRI CITRATIS.—The preparation of this solution depends on the fact that freshly precipitated ferric hydrate is soluble in the organic acids, in this instance citric acid. The ferric hydrate is prepared by pouring a diluted solution of ferric sulphate into well-diluted ammonia water, which must be in

* The finest piano wire contains about 99 per cent. of pure iron, but in the above given calculations it is assumed to be absolutely pure (100 per cent.).

slight excess. The precipitated ferric hydrate is well washed, to free it from adhering ammonium sulphate:—

$$\underset{\text{Ferric Sulphate.}}{Fe_2(SO_4)_3} + \underset{\text{Ammonia Water.}}{6NH_3 + 6H_2O} = \underset{\text{Ferric Hydrate.}}{Fe_2(OH)_6} + \underset{\text{Ammonium Sulphate.}}{3(NH_4)_2SO_4}$$

To be certain that all traces of ammonium sulphate have been removed, the wash-water acidulated with hydrochloric acid is tested with barium chloride T. S., which should not give a white cloud or precipitate ($BaSO_4$). In the above case we employ diluted cold solutions, in order to obtain a light flocculent precipitate, which is more readily dissolved by the citric acid:—

$$\underset{\text{Ferric Hydrate.}}{Fe_2(OH)_6} + \underset{\text{Citric Acid.}}{2(H_3C_6H_5O_7 + H_2O)} = \underset{\text{Ferric Citrate.}}{Fe_2(C_6H_5O_7)_2} + \underset{\text{Water.}}{8H_2O}$$

Care should be taken that the solution be not heated above 60° C., otherwise insoluble oxycitrates will form. When this solution is employed in making scale salts, the operator should satisfy himself that the ferric sulphate solution is of full strength, otherwise the citric acid will not be sufficiently saturated and fail to "scale." The solution is used in making the scale salts Ferri Citras and Ferri et Ammonii Citras.

Assay.—On adding 1.117 Gm. of the solution to water and hydrochloric acid, the citric acid is liberated and ferric chloride is formed; thus:—

$$\underset{\substack{\text{Ferric Citrate.}\\ 2 \times 55.8\ \text{Fe.}}}{Fe_2(C_6H_5O_7)_2} + \underset{\text{Hydrochloric Acid.}}{6HCl} = \underset{\substack{\text{Ferric Chloride.}\\ 2 \times 55.8\ \text{Fe.}}}{Fe_2Cl_6} + \underset{\text{Citric Acid.}}{2H_3C_6H_5O_7}$$

Then, on addition of the potassium iodide, iodine is liberated and ferrous chloride with potassium chloride are formed:—

$$\underset{\substack{\text{Ferric Chloride.}\\ 2 \times 55.8\ \text{Fe.}}}{Fe_2Cl_6} + \underset{\text{Potassium Iodide.}}{2KI} = \underset{\text{Ferrous Chloride.}}{2FeCl_2} + \underset{\text{Potassium Chloride.}}{2KCl} + \underset{\substack{\text{Iodine.}\\ 2 \times 126.5.}}{I_2}$$

The liberated iodine is then estimated by dropping in decinormal solution of sodium hyposulphite in presence of starch, until the blue color disappears:—

$$\underset{\substack{\text{Sodium Hyposulphite.}\\ 2 \times 247.6}}{2(Na_2S_2O_3.5H_2O)} + \underset{\substack{\text{Iodine.}\\ 2 \times 126.5}}{I_2} = \underset{\text{Sodium Iodide.}}{2NaI} + \underset{\text{Sodium Tetrathionate.}}{Na_2S_4O_6} + \underset{\text{Water.}}{10H_2O}$$

One molecule of sodium hyposulphite (247.6 parts) unites with one atom of iodine (126.5 parts), this being liberated by one atom of iron (55.8 parts). Therefore, one molecule of the hyposulphite (247.6 parts) corresponds to one atom of iron (56.8 parts).

Then if	247.6	parts of hyposulphite	= 55.8	parts of iron,
(1000 Cc.)	24.76	" " "	= 5.58	" " "
(100 Cc.)	2.476	" " "	= 0.558	" " "
(10 Cc.)	0.2476	" " "	= 0.0558	" " "
(1 Cc.)	0.02476	" " "	= 0.00558	" " "

15 Cc. of the decinormal solution = 15 × 0.00558 = 0.0837 Gm. metallic iron.

Having taken 1.117+ Gm. of the solution, this would indicate that it contains about 7.5 per cent. [(0.0837 ÷ 1.117) × 100] of metallic iron; or, 7.5 per cent. of 1.117 Gm. = 0.0837 + Gm., the amount of metallic iron it should contain.

Exercise.—How much of 10 per cent. ammonia water is necessary to completely precipitate 100 Gm. of solution of ferric sulphate, U. S. P.? The 100 Gm. of ferric sulphate solution contain 8 Gm. of iron (8 per cent.). 1 molecule of ferric sulphate contains 2 atoms of iron (2 × 55.8), which require 6 molecules (6 × 17) of ammonia for precipitation. Hence, one atom (55.8 parts) of iron will require 3 molecules (3 × 17 parts) of ammonia:—

$$\begin{array}{ccccccc} Fe & & 3NH_3 & & Fe & & NH_3 \\ 55.8 & : & 51 & :: & 8 & : & x \end{array}$$
$$x = 7.31 \text{ Gm. } NH_3$$

7.31 Gm. of ammonia gas correspond to 73.10 Gm. of 10 per cent. ammonia water. Hence, 73.10 Gm. of 10 per cent. ammonia water are necessary to precipitate 100 Gm. ferric sulphate solution, U. S. P.

LIQUOR FERRI ET AMMONII ACETATIS (Basham's Mixture).—On mixing the ferric chloride and ammonium acetate solutions an interchange of radicals takes place, with the formation of ferric acetate and ammonium chloride, a beautiful red-colored, clear solution resulting. When made according to our present Pharmacopœia, it is stable and can be kept almost indefinitely; formerly, difficulties arose from the use of an alkaline solution of ammonium acetate and an insufficient amount of acetic acid; hence, on mixing the two, a precipitate of basic ferric acetate occurred either at once, or very soon afterward.

The preparation should be dispensed fresh.

LIQUOR FERRI NITRATIS.—This solution is made by dissolving ferric hydroxide in nitric acid: $Fe_2(OH)_6 + 6HNO_3 = Fe_2(NO_3)_6 + 6H_2O$,—a safe and agreeable method, and preferable to the shorter process of the British Pharmacopœia, in which the iron wire is dissolved in nitric acid. The last-mentioned reaction, being violent, requires great caution; moreover, the fumes evolved are also annoying.

This preparation is more astringent than the salts of iron with the organic acids.

LIQUOR FERRI SUBSULPHATIS (Monsel's Solution).—This is an aqueous solution of basic ferric sulphate. It is sometimes called persulphate of iron solution, which is inaccurate, and liable to be confounded with the solution of tersulphate of iron. On adding the pulverized ferrous sulphate to the heated mixed acids, the solution becomes of a black color, due to the uniting of the nitric oxide with the ferrous sulphate ($FeSO_4.NO$), which quickly disappears with evolution of red nitrous vapors. Should the solution remain of a dark (black) color, after all the ferrous sulphate has

been added, the addition of a few drops of nitric acid will be sufficient to cause the evolution of the nitric oxide, and the solution will then appear of a clear reddish-brown color. The tests for nitric acid and ferrous salt are the same as those given under Solution of Ferric Chloride. This solution contains a lesser amount of sulphuric acid and more of ferric sulphate than the tersulphate of iron, hence, instead of the normal ferric sulphate, a basic or oxysulphate (probably $Fe_4O(SO_4)_5$) is obtained. On standing, this solution sometimes deposits a sediment; this may be redissolved by placing the bottle in hot water. This solution may be distinguished from the tersulphate by adding one volume of sulphuric acid to two of the solution, when in the case of the subsulphate a white, semi-solid mass of basic or oxysulphate will separate.

The dry persulphate (Monsel's Powder) is obtained by evaporating the solution to dryness and powdering.

Both the solution and powder are used as local styptics in cases of hæmorrhage.

Liquor Ferri Tersulphatis.—A solution of normal ferric sulphate, or solution of persulphate of iron. This solution is weaker in iron and contains more sulphuric acid than Monsel's solution. It should contain about 28.7 per cent. of $Fe_2(SO_4)_3$.

On adding the ferrous sulphate (powdered), in portions, to the heated mixture of sulphuric and nitric acids, effervescence takes place, with evolution of vapors of nitric oxide (NO or N_2O_2). When all of the iron has been added, the solution should be clear and of a dark reddish-brown color. Should it be of a black color ($FeSO_4.NO$), this indicates that there is not a sufficient amount of nitric acid present to oxidize all of the ferrous to ferric sulphate, hence nitric acid should be added drop by drop until effervescence ceases and the solution clears up. The reaction takes place as follows:—

$$\underset{\substack{\text{Ferrous Sulphate.}\\ 6\times 277.4.}}{6FeSO_4 + 7H_2O} + \underset{\substack{\text{Sulphuric}\\ \text{Acid.}}}{3H_2SO_4} + \underset{\text{Nitric Acid.}}{2HNO_3} = \underset{\substack{\text{Ferric Sulphate.}\\ 3\times 399.2.}}{3Fe_2(SO_4)_3} + \underset{\text{Nitric Oxide.}}{N_2O_2} + \underset{\text{Water.}}{11H_2O}$$

Assay.—The process of assay is identical with that given under solution of Ferric Acetate or Chloride.

Exercise.—How many grammes of ferric sulphate ($Fe_2(SO_4)_3$) can be prepared from 400 Gm. of ferrous sulphate, $FeSO_4+7H_2O$?

Since according to the equation given above, 1664.4 parts of ferrous sulphate yield 1197.6 parts of ferric sulphate, hence

$$\underset{\text{Ferrous Sulphate.}}{1664.4} : \underset{\text{Ferric Sulphate.}}{1197.6} :: 400 : x$$

Therefore $x = 287 +$ grammes of ferric sulphate can be made from 400 grammes of ferrous sulphate.

Now, if this solution is made up so as to weigh 1000 Gm. (U. S. P.) it would necessarily contain 28.7 per cent. of the salt.

Liquor Hydrargyri Nitratis (Solution of Mercuric Ni-

trate.)—This solution is prepared by dissolving red mercuric oxide or metallic mercury in nitric acid:—

HgO	+	$2HNO_3$	=	$Hg(NO_3)_2$	+	$H_2O.$
Mercuric Oxide. 215.7		Nitric Acid.		Mercuric Nitrate. 323.6		Water.

If 40 Gm. of mercuric oxide are taken, we would obtain about 60 Gm. of mercuric nitrate:—

HgO		$Hg(NO_3)_2$		HgO		$Hg(NO_3)_2$
215.7	:	323.6	: :	40	:	x

$$x = 60 + \text{Gm.}$$

If the solution be made up to the weight of 100 Gm. (U. S. P.), it would then contain about 60 per cent. of this mercuric nitrate. This solution is employed as a caustic.

Liquor Iodi Compositus (Lugol's Solution, or Compound Solution of Iodine).—Free iodine is readily dissolved by an aqueous solution of potassium iodide. In the U. S. P. preparation we find 5 per cent. of iodine, and 10 per cent. of potassium iodide present. This is the best preparation adapted to the internal administration of iodine, as it does not precipitate when added to water.

This solution is a valuable reagent in testing for the presence of alkaloids in solution, since the latter unite with the iodine, forming insoluble double salts of a brown color. This fact should be remembered when Lugol's solution is directed to be added to any preparation containing an alkaloid.

Assay.—The amount of *free* iodine contained in this solution is estimated by titrating with decinormal solution of sodium hyposulphite in presence of starch; the end of the reaction being known by the disappearance of the blue color (iodide of starch). The reaction that takes place is as follows:—

$(Na_2S_2O_3 + 5H_2O)$	+	$2I$	=	$2NaI$	+	$Na_2S_4O_6$	+	$10H_2O$
Sodium Hyposulphite. 2 × 247.6		Iodine. 2 × 126.6		Sodium Iodide.		Sodium Tetrathionate.		Water.

	Sodium Hyposulphite.	Iodine.
	2 × 247.6 parts	2 × 126.6 parts.
	247.6 "	126.6 "
1000 Cc. $\frac{N}{10}$ V. S.	24.76 Gm.	12.66 Gm.
1. Cc. $\frac{N}{10}$ V. S.	0.0248 Gm.	0.01266 Gm.

If 50 Cc. of the Hyposulphite solution were consumed in decolorizing 12.66 Gm. of the Lugol's Solution, then the amount of iodine present in the sample would be $50 \times 0.01266 = 0.633$ Gm., corresponding to 5 per cent [$(0.633 \div 12.66) \times 100$].

Liquor Magnesii Citratis.—On bringing citric acid and magnesium carbonate in contact in presence of water, carbonic acid gas is given off, and magnesium citrate is formed; according to the proportions of the two, either the acid ($MgHC_6H_5O_7$) or normal ($Mg_3C_6H_5O_7$) salt or a mixture of the two is formed. The first-mentioned is the more desirable, because of its solubility and the greater permanence of the solution. When the solution

contains less soluble normal salt, it will not keep well for any length of time. The pharmacopœial preparation contains both the acid and normal salts, and is not calculated to keep long without precipitation. It would be well to increase the amount of citric acid by about 3 Gm. There should be sufficient citric acid present in this solution to combine with the magnesia, as well as to react with the potassium bicarbonate, so as to produce the necessary amount of carbonic acid, which is so desirable in this solution. Boiled or distilled water only should be used in making this preparation.*

LIQUOR PLUMBI SUBACETATIS (Goulard's Extract, Acetum plumbicum or saturninum). On boiling lead acetate and oxide with water, there are obtained, according to the relative proportions of the two, various basic lead acetates, that of the U.S.P. being

$$\underset{\substack{\text{Lead Acetate.}\\378}}{Pb(C_2H_3O_2)_2 + 3H_2O} + \underset{\substack{\text{Litharge.}\\222.36}}{PbO} = \underset{\substack{\text{Lead oxyacetate.}\\546.4}}{Pb_2O(C_2H_3O_2)_2} + \underset{\text{Water.}}{3H_2O}$$

If 170 Gm. of lead acetate are employed, 245.74 Gm. of subacetate (oxyacetate) are obtained:—

Lead Acetate.		Lead Oxyacetate.		Lead Acetate.		Lead Oxyacetate.
378	:	546 4	: :	170	:	x

$x = 246$ Gm. Subacetate of Lead.

If the solution be made up to 1000 Gm., it will contain about 24.5 per cent. of the subacetate.

This solution is not of constant strength, since it readily absorbs carbonic acid, which precipitates the lead as carbonate. It should be prepared in a flask, in order to avoid contact with air as much as possible; only boiled distilled water should be employed in order to avoid any decomposition of the lead acetate from carbonic acid that may be present. The litharge should be first tested for carbonate by the addition of a little diluted nitric acid, and any sample which contains it should not be employed.

Solution of lead subacetate is incompatible with hydrochloric or sulphuric acid or preparations containing these; also with the soluble iodides, bromides or chlorides, alkalies, mucilage of acacia, many organic acids, tannin, and vegetable solutions (infusions, fluid extracts, etc.), which contain much coloring matter.

Exercise.—How much litharge should be taken to convert 170 Gm. of lead acetate into subacetate?

Since 378 Gm. of lead acetate require 222.36 Gm. of litharge to form the official subacetate, 170 Gm. of lead acetate will require 100 Gm. of litharge:—

Lead Acetate.		Litharge.		Lead Acetate.		Litharge.
378	:	222.3	: :	170	:	x

$x = 100$ (practically).

* It is also to be noted that the quantity of Syrup of Citric Acid should be reduced one-half (to 60 Gm.), the amount printed in the earlier issues of the U. S. P. (120 Gm.) being an error.

Assay.—The U. S. P. directs the assay of this solution by means of normal sulphuric acid, the reaction being as follows:—

$$\underset{\substack{\text{Lead Subacetate.}\\546.4}}{Pb_2O(C_2H_3O_2)_2} + \underset{\substack{\text{Sulphuric Acid.}\\2\times 97.8}}{2H_2SO_4} = \underset{\text{Lead Sulphate.}}{2PbSO_4} + \underset{\text{Acetic Acid.}}{2HC_2H_3O_2} + \underset{\text{Water.}}{H_2O}$$

Two molecules of sulphuric acid (2 × 97.8) are equivalent to one molecule of lead subacetate (546.4), hence:—

Sulphuric Acid—H_2SO_4.	Lead Subacetate—$Pb_2O(C_2H_3O_2)_2$.
1 molecule, 97.8 p,	273.2 p. (½ of 546.4).
1000 Cc. V. S. = 48.9 Gm.	136.6 Gm. (½ of 273.2).
1 Cc. V. S. = 0.489 Gm.	0.1366 Gm.

25 Cc V. S. = 25 × 0 1366 = 3.415 Gm. of lead subacetate, and since 13.67 Gm. of solution of Lead Subacetate were taken, it would then contain about 25 per cent. of the salt [(3.415 ÷ 13.67) × 100]; or 25 per cent. of 13.67 = 3.41 + Gm.).

LIQUOR PLUMBI SUBACETATIS DILUTUS, (Lead Water; Aqua plumbica or saturnina).—This is prepared by simply diluting the preceding solution with water, which should, however, be distilled and previously boiled; otherwise the solution will become turbid, and lose in strength, owing to a precipitation of a portion of the lead as carbonate.

LIQUOR POTASSÆ.—This is an aqueous solution containing about 5 per cent. of Potassium Hydrate (KOH). Besides the rapid method of dissolving the stick potassa in water, the Pharmacopœia directs it to be prepared from potassium carbonate, which in turn is made from the bicarbonate by boiling the latter with water; through loss of carbonic acid it is converted into normal carbonate:—

$$\underset{2\times 99.88}{2KHCO_3} = \underset{137.9}{K_2CO_3} + CO_2 + H_2O.$$

This solution is then boiled with slaked lime,

$$CaO + H_2O = Ca(OH)_2,$$

giving rise to potassium hydrate and calcium carbonate, thus:—

$$\underset{\substack{\text{Calcium}\\\text{Hydrate.}}}{Ca(OH)_2} + \underset{\substack{\text{Potassium}\\\text{Carbonate.}\\137.9.}}{K_2CO_3} = \underset{\substack{\text{Calcium}\\\text{Carbonate.}}}{CaCO_3} + \underset{\substack{\text{Potassium}\\\text{Hydrate.}\\2\times 56.}}{2KOH}$$

The solution is allowed to stand until clear, and decanted off from the precipitated calcium carbonate, or it may be directly filtered through spun glass or asbestos (fibrous). The commercial potassium carbonate (salt of tartar) contains silica and other impurities, hence the Pharmacopœia prefers to employ the pure bicarbonate. When prepared from the ordinary stick potassa, the solution is liable to deposit a gelatinous precipitate of silica on standing. The purest form of potassa in the market is that which is purified by alcohol, made by treating the commercial product with alcohol, which leaves the silica, carbonates, chlorides, etc., undissolved. The solution should be preserved in rubber-stoppered vessels, or should glass stoppers be used, they

should be well greased with petrolatum. The solution readily absorbs carbonic acid from the air.

It is incompatible with all solutions containing alkaloids, salts of metals, and also acids.

Assay.—The strength of this solution is estimated by its neutralizing power on normal sulphuric acid, according to the following equation:—

H_2SO_4	+	$2KOH$	=	K_2SO_4	+	$2H_2O$
Sulphuric Acid. 97.8.		Potassium Hydrate. 2×56.		Potassium Sulphate.		Water.

As two molecules of potassium hydrate neutralize one molecule of sulphuric acid, hence, *one* molecule of potassa will neutralize half a molecule of sulphuric acid.

Sulphuric Acid—$\frac{1}{2}H_2SO_4$.	Potassium Hydrate—KOH.
1000 Cc. containing 48.9 p., ...	56 p.
1 Cc. V. S. containing 0.0489 Gm., ...	0.056 Gm.

25 Cc. V. S. containing $25 \times 0.56 = 1.40$ Gm. potassium hydrate; now if 28 Gm. of the solution were taken, it would then contain 5 per cent. of the anhydrous salt $[(1.4 \div 28) \times 100]$, or 5 per cent. of $28 = 1.40$ Gm.

Exercise.—How much potassium hydrate can be made from 90 Gm. of potassium bicarbonate?

Since, according to the equation, 199.7 parts (2×99.88) of $KHCO_3$ yield 137.9 parts of K_2CO_3, hence, 90 Gm. of $KHCO_3$ will yield 62.1 + Gm. of K_2CO_3:—

$$\begin{array}{ccccccc} KHCO_3 & & K_2CO_3 & & KHCO_3 & & K_2CO_3 \\ 199.7 & : & 137.9 & :: & 90 & : & x \quad ; \quad x = 62.1 + \end{array}$$

Again, since 137.9 parts of K_2CO_3 when boiled with excess of slaked lime ($Ca(OH)_2$) will yield 112 parts of KOH (2×56), hence, 62.1 + Gm. of K_2CO_3 will under like circumstances yield 50.4 + Gm. of KOH:—

$$\begin{array}{ccccccc} K_2CO_3 & & KOH & & K_2CO_3 & & KOH \\ 137.9 & : & 112 & :: & 62.1 & : & x \quad ; \quad x = 50.4 + \end{array}$$

If the solution be made up to 1000 Gm., it will contain in round numbers 5 per cent. of potassa.

LIQUOR POTASSII ARSENITIS (Fowler's Solution).—This solution contains 1 per cent.* of arsenous acid (As_2O_3) in solution as potassium arsenite ($K_2As_2O_4$). On boiling potassium bicarbonate and arsenous acid together, the following reactions probably take place:—

(*a*) $2KHCO_3 + As_2O_3 + Aq = 2KAsO_2 + 2CO_2 + H_2O + Aq.$
Potassium metarsenite.

or (*b*) $4KHCO_3 + As_2O_3 + 3H_2O = 2K_2HAsO_3 + 4H_2O + 4CO_2.$
Potassium Bicarbonate. Arsenous Acid. Acid Potassium Orthoarsenite.

The German and British pharmacopœias employ normal potassium carbonate instead of the bicarbonate; a slight excess of alkaline carbonate remains in the solution. This solution should

* Practically 1 per cent., there being 10 Gm. of As_2O_3 in 1000 Cc. of solution, which weighs 1009 Gm.

not be kept longer than a year at the most, since it becomes weaker in therapeutic effect, owing to the gradual oxidation of the arsen*ous* to arsen*ic* acid; the arsenic salts being less potent than the arsenous. The solution should therefore be kept in well filled bottles. Only the *pure* arsenous acid in lumps should be used, and not the commercial, which is very often adulterated or impure.

The object of adding compound tincture of lavender is to impart sufficient taste and color to the solution to prevent its being mistaken for water.

The solution is incompatible with salts of iron, magnesium and calcium. In cases of arsenical poisoning, emetics, calcined magnesia or the official arsenic antidote, viz., ferric hydrate with magnesia, should be administered as soon as possible. The two latter form insoluble, inert double compounds with soluble arsenic salts.

Assay.—The pharmacopœial method consists in adding decinormal iodine V. S., to the solution of arsenous salt containing an excess of sodium bicarbonate and mixed with a little starch, until the blue color produced ceases to disappear. The addition of iodine to arsen*ous* acid in alkaline solution causes its oxidation to arsen*ic* acid, the iodine thereby being reduced to hydriodic acid, with disappearance of color. As soon as all of the arsenous is oxidized to arsenic acid, then the next drop of iodine (which is free) will strike a blue color with the starch added to the solution. The reaction is as follows:—

As_2O_3	+	$4I$	+	$4NaHCO_3$*	=	As_2O_5	+	$4NaI$	+	$4CO_2$	+	$2H_2O$
Arsenous Oxide. 197.68		Iodine. 4 × 126.5		Sodium Bicarbonate.		Arsenic Oxide.		Sodium Iodide.		Carbonic Acid.		Water.

The addition of the extra 2 Gm. of sodium bicarbonate serves the purpose of combining with the liberated hydriodic acid, which, if present in free condition, would interfere with the reaction. From the equation we see that 4 atoms of iodine (4 × 126.5) are necessary to oxidize one molecule (197.68) of arsenous to arsenic oxide. Hence, one atom of iodine is equivalent to ¼ of a molecule of arsenous oxide.

	Iodine.	Arsenous Oxide.
	126.5 parts.	49.42 parts.
1000 Cc. $\frac{N}{10}$ V. S. containing	12.65 Gm.	4.942 Gm.
1 Cc. $\frac{N}{10}$ V. S. containing	0.01265 Gm.	0.004942 Gm.

50 Cc. of $\frac{N}{10}$ V. S. Iodine $= 50 \times 0.004942 = 0.247 +$ Gm., As_2O_3

Hence, if 24.7 Cc. of the solution had been taken, and 0.247 Gm. of arsenous oxide were found contained in it, then the solution must be of 1 per cent. strength.†

Exercise.—If 10 Gm. of a sample of Fowler's solution required 18 Cc. of $\frac{N}{10}$ iodine volumetric solution to produce a blue color,

* The $NaHCO_3$ merely plays the part of a solvent for the As_2O_3, hence the formula $KAsO_2$ or ($NaAsO_2$) is not used here. † See Footnote, page 238.

under the conditions given in the U. S. P., what per cent. of arsenous oxide would it contain?

Since 1 Cc. of $\frac{N}{10}$ iodine volumetric solution = 0.004942 Gm. of As_2O_3, hence, 18 Cc. of $\frac{N}{10}$ iodine volumetric solution = 18 × 0.004912 = 0.0889 + Gm. of As_2O_3. If 10 Gm. of the solution had been taken, then (0.0889 ÷ 10) × 100 = 0.8.

The sample, therefore, contains $\frac{8}{10}$ per cent. of As_2O_3.

LIQUOR POTASSII CITRATIS.—The reaction that takes place on mixing solutions of citric acid and potassium bicarbonate is as follows:—

$$\underset{\substack{\text{Potassium Bicarbonate.}\\ 3 \times 99.8}}{3KHCO_3} + \underset{\substack{\text{Citric Acid.}\\ 209.5}}{H_3C_6H_5O_7 + H_2O} = \underset{\substack{\text{Neutral Potassium Citrate.}\\ 305.6}}{K_3C_6H_5O_7} + 4H_2O + 3CO_2$$

The solution contains neutral potassium citrate with free citric and carbonic acids, the latter imparting a pleasant acidulous taste to the solution. The solution should always be dispensed fresh.

Exercise.—How much citric acid will be necessary to neutralize 8 Gm. of potassium bicarbonate; also how much potassium citrate will be produced?

If 299.4 parts of $KHCO_3$ require 209.5 parts of $H_3C_6H_5O_7$, then 8 Gm. of $KHCO_3$ will require 5.6 — Gm. of $H_3C_6H_5O_7$:—

$$\begin{array}{ccccccc} 3KHCO_3 & & H_3C_6H_5O_7 & & KHCO_3 & & H_3C_6H_5O_7 \\ 299.4 & : & 209.5 & :: & 8 & : & x \end{array}$$
$$x = 5.6 -$$

If 299.4 parts of $KHCO_3$, when neutralized with citric acid, will yield 305.6 parts of potassium citrate, then 8 Gm. of $KHCO_3$ will yield 8.1 + Gm. of $K_3C_6H_5O_7$:—

$$\begin{array}{ccccccc} 3KHCO_3 & & K_3C_6H_5O_7 & & KHCO_3 & & K_3C_6H_5O_7 \\ 299.4 & : & 305.6 & :: & 8 & : & x \end{array}$$
$$x = 8.1 +$$

LIQUOR SODÆ.—This solution, like that of potassa, can be made by dissolving the caustic alkali in the necessary amount of water, or by boiling the necessary quantity of the carbonated alkali and slaked lime together with water. Thus:—

$$\underset{\substack{\text{Sodium Carbonate.}\\ 285.4}}{Na_2CO_3 + 10H_2O} + \underset{\substack{\text{Calcium}\\ \text{Hydrate.}}}{Ca(OH)_2} = \underset{\substack{\text{Sodium}\\ \text{Hydrate.}\\ 2 \times 40}}{2NaOH} + \underset{\substack{\text{Calcium}\\ \text{Carbonate.}}}{CaCO_3} + \underset{\text{Water.}}{10H_2O}$$

The method of preparation and preservation, and the incompatibles, are the same as those given under Liquor Potassæ.

Assay.—The method of assay is also the same as that of Liquor Potassæ:—

$$\underset{\substack{\text{Sulphuric Acid.}\\ 98.8}}{H_2SO_4} + \underset{\substack{\text{Sodium Hydrate.}\\ 2 \times 40}}{2NaOH} = \underset{\text{Sodium Sulphate.}}{Na_2SO_4} + \underset{\text{Water.}}{2H_2O}$$

	Sulphuric Acid. 97.8 p.		Sodium Hydrate. 2 × 40 p.
1000 Cc. V. S., containing, ...	48.9 Gm.	=	40 Gm.
1 Cc. V. S., containing, ...	0.489 Gm.	=	0.040 Gm.

25 Cc. V. S. H_2SO_4 = 25 × 0.040 = 1.0 Gm. of sodium hydrate.

Hence, if 20 Gm. of the solution were taken, it would contain 5 per cent. of sodium hydrate [(1.0 ÷ 20) × 100].

LIQUOR SODII ARSENATIS.*—This is a form of administering the official sodium arsenate (Na_2HAsO_4), containing 1 per cent. of the salt. The dose, antidotes, and uses are the same as that of Fowler's Solution.

LIQUOR SODÆ CHLORATÆ (Solution of Chlorinated Soda.—Labarraque's Solution).—The value of this solution depends upon the amount of sodium hypochlorite present, which should yield, according to the U. S. Pharmacopœia, 2.6 per cent. by weight of available chlorine.

The reaction which takes place on mixing the solutions of chlorinated lime and sodium carbonate is most probably as follows:—

$$\underbrace{Ca(OCl)_2 + CaCl_2}_{\text{Chlorinated Lime.}} + \underbrace{2Na_2CO_3}_{\text{Sodium Carbonate.}} = \underbrace{2NaOCl}_{\text{Sodium Hypochlorite.}} + \underbrace{2NaCl}_{\text{Sodium Chloride.}} + \underbrace{2CaCO_3}_{\text{Calcium Carbonate.}}$$

Hot water is used for the purpose of rendering the precipitate of calcium carbonate as dense as possible, so that it may rapidly settle.

Labarraque's Solution is a superior disinfectant, but it is also employed as an antiseptic. When used as a wash it should be diluted with 5 to 10 parts of water. The addition of acids or acid salts to the solution causes it to give off chlorine gas.

It is incompatible with the iodides and bromides, causing a liberation of iodine or bromine; likewise incompatible with many metallic salts and many organic substances A preparation analogous to this in every respect is the Liquor Potassæ Chloratæ, or Javelle water.

Assay.—The assay method is based on the fact that the chlorine liberates an equivalent amount of iodine from potassium iodide (the chlorine itself being set free by the addition of HCl); this liberated iodine is then estimated by means of decinormal sodium hyposulphite, V. S.† If, then, we know how much iodine has been liberated, the amount of chlorine present is readily calculated.

On adding the hydrochloric acid to the solution, all of the *available* chlorine is liberated:—

$$NaOCl + 2HCl = NaCl + H_2O + Cl_2.$$

Then for every atom (35.3) of chlorine liberated, one atom (126.6) of iodine is set free from its combination in the potassium iodide; thus:—

$$\underset{\substack{\text{Chlorine.}\\2 \times 35.3}}{2Cl} + \underset{\substack{\text{Potassium Iodide.}\\2 \times 126.6}}{2KI} = \underset{\text{Potassium Chloride.}}{2KCl} + \underset{\text{Iodine.}}{I_2}$$

* Pearson's Solution is sometimes confounded with this, but is ten times weaker, containing about $\frac{1}{10}$ per cent. of anhydrous Sodium Arseuate.

† See Decinormal Sodium Hyposulphite Solution.

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Starch being added to the solution, the latter is colored blue by the free iodine. To this solution is added, drop by drop, the decinormal solution of sodium hyposulphite, until the blue color disappears; thus:—

$2(Na_2S_2O_3.5H_2O)$	+	I_2	=	$2NaI$	+	$Na_2S_4O_6$	+	$10H_2O$
Sodium Hyposulphite. 2×247.6		Iodine. 2×126.6		Sodium Iodide.		Sodium Tetrathionate.		Water.

Since 247.6 parts of hyposulphite are equivalent to 126.6 parts of iodine, and this is liberated by 35.3 parts of chlorine, one molecule of the hyposulphite is equivalent to one atom of chlorine.

$$\frac{2Na_2S_2O_3 5H_2O}{2 \times 247.6} = \frac{2I}{2 \times 126.6} = \frac{2Cl}{2 \times 35.3}.$$

or 247.6 p. = 126.6 p. = 35.3 p.

hence 247.6 p. . . . . 35.3 p.

1000 Cc. of the Sodium Hyposulphite, V.S. = 24.76 Gm. . 3.53 Gm.

1 Cc. of the Sodium Hyposulphite, V.S. = 0.2476 Gm. 0.00353 Gm.

50 Cc. = 50 × 0.00353 = 0.1765 Gm. of chlorine.

If 6.74 Gm. of the solution was taken, and it were found to contain 0.1765 Gm. of chlorine gas, then the per cent. of available chlorine would be [(0.1765 ÷ 0.74) × 100] = 2.6 + per cent.

Exercise.—If, in making up Labarraque's Solution according to the U. S. P., the chlorinated lime taken was found to contain 30 per cent. of available chlorine, what should be the chlorine strength of the finished product?

If 75 Gm. of the chlorinated lime are taken, and 30 per cent. of this is available chlorine, then the amount of chlorine in the finished 1000 Gm. of product would be 30 per cent. of 75, or 22.5 Gm. or 2.25 per cent. Hence the solution would contain 2.25 per cent. of available chlorine.

LIQUOR SODII SILICATIS ("Soluble Glass").—This is made by fusing together 1 part of fine white sand and 2 parts of dried sodium carbonate, and dissolving the product in boiling water, filtering, and evaporating. It is used in bandaging in surgery. The commercial solution contains about 30 to 35 per cent. of sodium silicate.

LIQUOR ZINCI CHLORIDI (Burnett's Disinfectant).—Since commercial zinc contains iron as an impurity, nitric acid is added to the solution, for the purpose of oxidizing the ferrous to ferric chloride (see page 230).

Zn	+	$2HCl$	=	$ZnCl_2$	+	H_2
Zinc. 65		Hydrochloric Acid. 2×36.3		Zinc Chloride. 135.8		Hydrogen.

The solution is evaporated to dryness and the residue fused to remove all nitric acid; some zinc carbonate is then added, whereby the iron is precipitated as insoluble ferric oxide, and this is then filtered off by pouring the solution through a pledget of spun glass or fibrous asbestos.

Fe_2Cl_6	+	$3ZnCO_3$	=	$Fe_2(CO_3)_3$	+	$3ZnCl_2$
Ferric Chloride.		Zinc Carbonate.		Ferric Carbonate.		Zinc Chloride.

$Fe_2(CO_3)_3$	=	Fe_2O_3	+	$3CO_2$
Ferric Carbonate.		Ferric Oxide.		Carbonic Acid.

The solution is a powerful disinfectant, also a valuable wash when properly diluted with water.

Exercise.—How much anhydrous zinc chloride can be made from 240 Gm. of pure metallic zinc?

Since, according to the above equation, 65 parts of zinc will yield 135.8 parts of zinc chloride, 240 Gm. of zinc will yield 538.3 + Gm. of zinc chloride.

$$\begin{array}{ccccccc} Zn & & ZnCl_2 & & Zn & & ZnCl_2 \\ 65 & : & 145.8 & :: & 240 & : & x \end{array}$$
$$x = 538.3$$

LIQUORES, U. S. P.

Title.	*Main Constituent.**	*Synonym.*
LIQUOR		
Acidi Arsenosi, ...	Arsenous Acid, 1 %.	
Ammonii Acetatis, . .	Ammonium Acetate, ab. 7 %.	Spirit of Mindererus.
Arseni et Hydrargyri Iodidi, ...	Arsenic Iodide, 1 %; Mercuric Iodide, 1 %.	Donovan's Solution.
Calcis, ...	Calcium Hydrate, 0.17 %.	Lime Water.
Ferri Acetatis, ...	Anhydrous Ferric Acetate, 31 %.	
Ferri Chloridi, ...	Anhydrous Ferric Chloride, 37.8 %.	
Ferri Citratis, ...	Circa, 43 % Ferric Citrate.	
Ferri et Ammonii Acetatis, ...	Ammonium Acetate.	Basham's Mixture.
Ferri Nitratis, ...	Anhydrous Ferric Nitrate, 6.2 %.	
Ferri Subsulphatis, . .	Basic Ferric Sulphate.	Monsel's Solution.
Ferri Tersulphatis, . .	Ferric Sulphate, 28.7 %.	
Hydrargyri Nitratis, .	Mercuric Nitrate, 60 %.	
Iodi Compositus, . . .	Iodine, 5 %; KI, 10 %.	Lugol's Solution.
Magnesii Citratis, . . .	Magnesium Citrates.	
Plumbi Subacetatis, .	Lead Subacetate, 25 %.	Goulard's Extract.
Plumbi Subacetatis Dilutus, ...	Lead Subacetate.	Lead Water.
Potassæ, ...	Potassium Hydrate, 5 %.	
Potassii Arsenitis, . . .	Arsenous Acid, 1 %.	Fowler's Solution.
Potassii Citratis, . . .	Anhydrous Potassium Citrate, 9 %.	Neutral Mixture.
Sodæ, ...	Sodium Hydrate, 5 %.	
Sodæ Chloratæ, ...	Available Chlorine, 2.6 %.	Labarraque's Solution.
Sodii Arsenatis, ...	Sodium Arsenate, 1 %.	Harle's Solution.
Sodii Silicatis, ...	Sodium Silicate.	
Zinci Chloridi, ...	Zinc Chloride, 50 %.	Burnett's Disinfecting Solution.

* The expression per cent., as employed in some instances, as Liquor Potassii Arsenitis, Acidi Arsenosi, etc., is strictly speaking inaccurate, because in these instances a definite *weight* of the active agent is contained in a definite *volume* of product: the volume (expressed in Cc.), does not always correspond to weight (Gm.). For example, the specific gravity of Fowler's Solution is 1.009, that is, 1000 Cc. weighs 1009 Gm.; it would then contain $\frac{99}{100}$ per cent. of Arsenous Acid, instead of 1 per cent. See page 137.

INFUSA.

INFUSIONS (*infundo*, I pour in) are aqueous solutions of the soluble principles of drugs, obtained by maceration in hot or cold water. They differ from decoctions in that a lower degree of heat is employed. Infusions are usually prepared from drugs which contain volatile principles, such as chamomile, valerian, cascarilla, etc., since the process of decoction, requiring a higher degree or a longer application of heat, would not only destroy these principles, but also extract much inert starchy and extractive matter.

The drug should be in a coarsely comminuted condition for hot infusions; for cold infusions, where percolation is resorted to, the drug should be in coarse powder.

Infusions are usually made by pouring boiling water upon the drug contained in a suitable well-covered vessel, then allowing it to stand (macerate) until cold, or for a specified period (for instance, one-half hour), as directed in the U. S. P. Other Pharmacopœias direct that after the addition of boiling water the vessel (well closed) be placed on a steam-bath and allowed to "digest" for 5 or 10 minutes. The process of cold percolation is employed only in the U. S. Pharmacopœia (Infusum Cinchonæ, Infusum Pruni Virginianæ).

The general strength of infusions, unless otherwise specified (as should be done in the case of potent drugs), is 1 part of the drug, in coarsely comminuted condition, to 20 parts of the finished product. The twenty parts of boiling water are poured upon the drug, and the mixture allowed to macerate for half an hour. It is then strained, with little or no pressure, enough hot water being poured through the strainer to make the product up to the desired quantity.

In preparing infusions of aromatic drugs or of such as contain volatile principles, the operator should exercise some judgment and care, for in these cases prolonged contact with hot water may injure or destroy these principles, and too high a temperature may extract starch and inert matter.

Infusions are best prepared by suspending the drug contained in a porous container* in the upper part of the infusion vessel, thereby securing its exhaustion by means of circulatory displacement. The water, on becoming saturated, sinks to the bottom, displacing a fresh portion, which rises so as to come into contact with the drug. This method renders it unnecessary to stir the mixture. Such a form of infusion pot is found in that devised by Squire (Fig. 325), which consists of a plain porcelain pot, in which is suspended a perforated diaphragm for holding the drug, the whole being covered by a well-fitting lid. The hot or cold water is poured into the pot until the drug is just covered; the pot is then covered and set aside for the specified time, when the

---

* The drug must be coarse enough not to fall through the perforations.

infusion is poured off. If the volume is not sufficient, an additional quantity of water is poured over the drug until the desired quantity is obtained. When such a mug is not at hand, an ordinary porcelain teapot may be used, in which the drug, contained in a bag of cheese-cloth, is suspended (by means of a string, through the hole in the lid) in the hot water. Both of these methods render straining unnecessary. Fig. 326 illustrates another form of tinned copper infusion mug in which the inner vessel, *a-d*, is suspended in an outer bath, *b-c*, which contains boiling water, the entire vessel being placed upon a gas stove.

The process of percolation is employed in making infusions of those drugs the active principles of which are readily taken up by cold water. Percolation can be successfully applied to infu-

FIG. 325.

Squire's Infusion Mug.

FIG. 326.

Infusion Mug with Bath.

sions, since the proportion of water to drug is relatively very large; hence exhaustion is insured.

Infusions which contain volatile oils will keep much longer and better than those not containing them, or those in which albuminous and mucilaginous matters predominate. Preservative agents, such as alcohol, boric or salicylic salts, etc., should not be used unless specially ordered; it is often advisable to heat the infusion to the boiling point, and to transfer it, while hot, to small bottles, which should be entirely filled, corked, and sealed.

Infusions should not be made from fluid extracts.

An aqueous infusion of a drug will often have an entirely different therapeutic effect from an alcoholic or hydro-alcoholic preparation of the same, since the different menstrua will dissolve out

different principles or different proportions of the principles. Thus, an aqueous infusion of digitalis is a powerful diuretic, while a preparation made by adding the corresponding amount of fluid extract or tincture of digitalis to water will be but feebly diuretic, but act powerfully upon the heart.

Moreover, the addition of concentrated alcoholic or fluid extracts to water is nearly always accompanied by precipitation, which renders the preparation so unsightly as to necessitate filtration, and this, if done, will often remove, practically, most of the activity, the result being a worthless preparation. Besides, the introduction of alcohol into the preparations which is caused thereby, is, in many cases, seriously objected to by the physician. It is a direct violation of the pharmacopœial instructions and of the intentions of the physician.

Infusions are incompatible with salts of the heavy metals, such as iron, mercury, silver, etc.

INFUSA, U. S. P.

Title.	*Per Cent. of Active Constituent.**	*Properties—Dose.*
BY MACERATION.		
Infusum Digitalis, . .	Digitalis, 1.5 %.	Diuretic, etc., 4 to 15 Cc.
Infusum Sennæ Compositum, ...	Senna, 6 %; $MgSO_4$ and Manna, each 12 %.	Purgative, 30 to 80 Cc.
BY PERCOLATION.		
Infusum Cinchonæ, . .	Cinchona, 6 %.	Tonic, 30 to 60 Cc.
Infusum Pruni Virginianæ, ...	Wild Cherry Bark, 4 %.	Tonic, Sedative, 30 to 90 Cc.

* See Footnote on page 225.

DECOCTA.

Decoctions (*decoquo*, I boil thoroughly) are aqueous solutions of the soluble matter of drugs, obtained by boiling with water. Decoctions are prepared from those drugs the active principles of which are not materially injured or dissipated by heat and are not readily extracted by cold or warm water. The process should be performed with care, so as to avoid subjecting the drug to too high a degree or too long an application of heat, for it must not be forgotten that with increase of the amount of extractive present the boiling point rises. The form of infusion mug illustrated in Fig. 326 may be employed for this purpose; since the inner vessel is heated by a water bath, there is no danger of the drug becoming overheated or charred, as is very liable to happen when the operation is carried on in a vessel over a direct flame.

Earthenware vessels are generally preferred for making decoctions. However, tinned copper answers just as well. Iron or tinned iron vessels should not be employed, because of the discoloration of infusions caused by tannin present in many drugs.

The general method for the preparation of decoctions when the strength is not specified (which should be done in the case of potent drugs) is as follows: The substance (1 part), in a coarsely comminuted condition, is placed in a suitable vessel provided with a well-fitting cover, together with 20 parts of cold pure water. The vessel is then covered and the contents boiled for fifteen minutes. When the temperature has fallen to about 40° C., the mixture is expressed and strained, and sufficient cold water passed through the strainer to make the finished product measure 20 parts by volume.

On standing, decoctions usually deposit a sediment which should not be removed. What has been said about the preservation and incompatibles of infusions, may also be applied to decoctions. Decoctions should, for like reasons, not be prepared from fluid extracts.

DECOCTA, U. S. P.

Title.	*Per Cent. of Main Constituents.**	*Properties.*
Decoctum Cetrariæ, . . .	Iceland Moss, 5 %.	Demulcent.
" Sarsaparillæ Compositum, ...	Spl'a., 10 %; Sasf., 2 %; Guaiac, 2 %; Glycyr., 2%; Mezereum, 1 %.	Alterative.

* See Footnote on page 225.

MUCILAGINES.

MUCILAGES are aqueous, viscid and adhesive solutions. Under this term, the U. S. Pharmacopœia understands a solution of a plant gum, or substance of a mucilaginous nature, obtained either by direct solution of a gum or by the extraction of a drug with water. In other pharmacopœias this term is made to embrace also solutions of starch and dextrin. Mucilages are very prone to ferment, becoming sour and offensive; they should therefore be made in small quantities, and preserved in well-closed jars in a cool place.

These solutions may be prepared by suspending the substance, enclosed in a bag of cheese-cloth, in a vessel of hot or cold water. In some instances it is desirable to employ water impregnated with the soluble parts of tolu (tolu water) as solvent, the presence of the balsam tending to preserve the preparation from fermentation. Other preservative agents may sometimes be used, particularly when the mucilage is not intended for internal use. Thus, mucilage of acacia may be preserved by the addition of about 10 grains of chloral to the ounce.

MUCILAGINES, U. S. P.

Title.	*Per Cent. of Main Constituents.**
COLD PROCESS.	
Mucilago Acaciæ	Acacia, 34 %.
" Sassafras Medullæ	Sassafras Pith, 2 %.
HOT PROCESS.	
Mucilago Tragacanthæ †	Tragacanth, 6 % ; Glycerin, 18 %.
" Ulmi	Elm, 6 %.

* See Footnote on page 225.

† This may be quickly prepared by placing the powdered tragacanth in a dry graduate, adding sufficient alcohol to form a thin, smooth paste, then pouring in the necessary amount of boiling water, agitating constantly with a spatula until a thin, smooth mucilage results.

CHAPTER XXVII.

ACETOUS SOLUTIONS.

ACETA—(*Vinegars*).

MEDICATED VINEGARS are solutions of medicinal principles in diluted acetic acid (or vinegar). This class of preparations was formerly made by using vinegar as a solvent, but, owing to the presence in the latter of extractive matters, and its variable strength, they were prone to undergo decomposition upon standing. Hence to secure the permanency of the preparation, diluted acetic acid of definite strength has been substituted for vinegar. This has peculiar solvent powers, in that it takes up many organic principles (alkaloids, glucosides, etc.) which are not soluble in water alone. These vinegars, even when prepared with diluted acetic acid, are prone to deposit a sediment and to undergo fermentation, for which reason some pharmacopœias direct the addition of a small amount of alcohol to the finished preparation. The U. S. Pharmacopœia has adopted the uniform drug strength of 10 per cent., employing the official diluted acetic acid, containing 6 per cent. by weight of absolute acid, as menstruum.

There are two vinegars official, viz., Acetum Opii (so-called Black Drop) and Acetum Scillæ; these are made by the process of *maceration*.

Title.	*Active Constituent.**	*Properties—Dose.*
Acetum Opii (Black Drop),	Opium, 10 %.	Sedative, 0.3–1 Cc.
Acetum Scillæ, ...	Squill, 10 %.	Expectorant, 1–3 Cc.

* See Footnote on page 225.

CHAPTER XXVIII.

ALCOHOLIC OR HYDROALCOHOLIC SOLUTIONS.

SPIRITUS—(*Spirits*).

SPIRITS are alcoholic solutions of volatile substances. According to the nature of the substance dissolved and the method of procedure, we may divide the 25 official spirits into three classes, viz., those prepared by

1. Solution in Alcohol. 2. Chemical Reaction and Solution. 3. Distillation.

The Spirits should be kept in well stoppered vials in a cool place.

1. SPIRITS PREPARED BY SOLUTION IN ALCOHOL.

These are made by dissolving or macerating the substance or substances directly in alcohol. In preparing the so-called *essences*, only the best quality of volatile oils should be employed; in three instances maceration is called for (Sp. Limonis, Menthæ piperitæ, and Menthæ viridis).

Title.	*Active Constituents.*	*Use—Dose.*
SPIRITUS		
Ætheris,	Ether, 32.5 % vol.	Stimulant, 3–10 Cc.
Ætheris Compositus,	Ether, 32.5 % vol. Ethereal Oil, 2.5 % vol.	Anodyne, 2–6 Cc.
Ammoniæ,*	Gaseous Ammonia, 10 % wt.	Stimulant, 0.5–2 Cc.
Ammoniæ Aromaticus,	Ammonia Carb. Ammonia Water. Oils, Lemon, Lavender, Nutmeg.	Stimulant, 2–4 Cc.
Amygdalæ Amaræ,	Oil, 1 % vol.	Flavor.
Anisi,	Oil, 10 % vol.	Flavor.
Aurantii,	Oil, 5 % vol.	Flavor.
Aurantii Compositus,	Oil, Orange, 20 % vol. Oil, Lemon, 5 % vol. Oil, Coriander, 2 % vol. Oil, Anise, ½ % vol.	Flavor.
Camphoræ,	Camphor, 10 % wt.	Stimulant; Sedative, 0.3-4 Cc.
Chloroformi,	Chloroform, 6 % vol.	Sedative, 0.6–4 Cc.
Cinnamomi,	Oil, 10 % vol.	Stimulant, 1 Cc.
Gaultheriæ,	Oil, 5 % vol.	Flavor.
Glonoini,	$C_3H_5(NO_3)_3$ 1 % wt.	Cardiac Stimulant, 0.06–0.1 Cc.
Juniperi,	Oil, 5 % vol.	Diuretic, 2–4 Cc.
Juniperi Compositus,	Oil, Juniper, 0.4 % vol. Oil, Caraway, 0.05 % vol. Oil, Fennel, 0.05 % vol.	Diuretic, 7–15 Cc.

* Some pharmacopœias recognize this under the title of Liquor Ammonii Caustici Spirituosus.

Title.	Active Constituents.	Use—Dose.
Lavandulæ, ...	Oil, 5 % vol.	Flavor.
Limonis, ...	Oil, 5 % vol.; Peel, 5 % wt.	Flavor.
Menthæ Piperitæ, . .	Oil, 10 % vol.; Herb, 1 % wt.	Carminative, 1-2 Cc.
Menthæ Viridis, . . .	Oil, 10 % vol.; Herb, 1 % wt.	Carminative, 1-2 Cc.
Myrciæ, ...	Oil, Bay, 0.8 % vol. Oil, Orange, 0.05 % vol. Oil, Allspice, 0.05 % vol.	Externally.
Myristicæ, ...	Oil, 5 % vol.	Flavor.
Phosphori, ...	Phosphorus, 0.12 % wt.	Elixir Phosphori.

2. SPIRITS PREPARED BY CHEMICAL ACTION AND SOLUTION.

There is but one spirit official which belongs to this class, viz., Spiritus Ætheris Nitrosi. By the reaction between nitrous acid (derived from sodium nitrite) and alcohol, ethyl nitrite is produced; and this is preserved by solution in alcohol. The solution should contain 4 per cent. of ethyl nitrite.

3. SPIRITS PREPARED BY DISTILLATION.

Aside from the two given under this class, some of those of Class 1 may be prepared by distillation, yielding a product of a more delicate flavor and odor than that produced by mere solution.

Title.	Preparation.	Per Cent. of Alcohol.
Spiritus Frumenti, . . .	Distillation of mash of fermented grain, and at least 2 years old.	44 % to 50 % wt., or 50 % to 58 % vol.
Spiritus Vini Gallici, . .	Distillation of fermented juice of grapes, and at least 4 years old.	39 % to 47 % wt., or 46 % to 55 % vol.

EXPLANATORY.

Spiritus Ætheris Nitrosi (Sweet Spirit of Nitre).—This is an alcoholic solution of ethyl nitrite (C_2H_5ONO or $C_2H_5NO_2$) an organic compound belonging to the class of esters. This was made, according to the U. S. Pharmacopœia of 1880, by the action of nitric acid on alcohol:—

$$\text{(a)}\quad \underset{\text{Alcohol.}}{C_2H_5OH} + \underset{\text{Nitric Acid.}}{HNO_3} = \underset{\text{Acetic Aldehyde.}}{CH_3COH} + \underset{\text{Nitrous Acid.}}{HNO_2} + \underset{\text{Water.}}{H_2O}$$

$$\text{(b)}\quad \underset{\text{Acetic Aldehyde.}}{CH_3COH} + \underset{\text{Nitric Acid.}}{HNO_3} = \underset{\text{Acetic Acid.}}{CH_3COOH} + \underset{\text{Nitrous Acid.}}{HNO_2}$$

$$\text{(c)}\quad \underset{\text{Alcohol.}}{C_2H_5OH} + \underset{\text{Nitrous Acid.}}{HNO_2} = \underset{\text{Ethyl Nitrite.}}{C_2H_5NO_2} + \underset{\text{Water.}}{H_2O}$$

This process was objectionable for two reasons: first, because the operation is difficult to regulate, and dangerous to the inexperienced operator; and second, because the product is largely contaminated with aldehyde (also acetic ether), which soon oxidize to acetic acid, causing a gradual decomposition of the ester.

The present pharmacopœia process possesses the advantage, that it is easily operated and controlled, and that it yields a pure

ethyl nitrite, free from aldehyde and acetic ether. The nitrous acid is produced by the reaction between sodium nitrite and sulphuric acid ($NaNO_2 + H_2SO_4 = NaHSO_4 + HNO_2$) in the presence of alcohol; * hence, the liberated acid reacts in *statu nascendi* upon the alcohol, with immediate production of ethyl nitrite, which distills over, contaminated with alcohol and free nitrous acid. These latter two are removed by pouring the entire distillate into a separating flask containing a solution of the sodium carbonate in ice-cold water, then washing the ethyl nitrite (which floats on the surface as a yellowish-colored liquid) by rotating (not shaking); the alkaline solution absorbs the alcohol and nitrous acid. The aqueous solution is then drawn off, and any trace of water remaining in the ethyl nitrite is removed by shaking it with a little dry potassium carbonate. This operation should not be performed in the neighborhood of a stove or gas flame, because of the extreme volatility and inflammable nature of the ester. It is well to place the separating flask on ice at intervals while operating.

The presence of water and the action of sunlight and air on pure spirit of nitre cause its rapid decomposition (shown by its acid reaction) by the splitting up of ethyl nitrite into nitrous acid and alcohol; hence the preparation should be preserved in well-stoppered vials in a cool and dark place. Spirit of nitrous ether should never be kept in large vessels (carboys), since, owing to its volatile nature, it rapidly loses strength. Acetic acid frequently occurs in samples of the commercial spirit; this is due to its having originally contained aldehyde, which, under ordinary conditions, rapidly oxidizes to acetic acid ($CH_3COH + O = CH_3$-$COOH$), imparting an acid reaction to the preparation, and causing effervescence when a crystal of potassium bicarbonate is dropped into it.

Only the deodorized alcohol of the U. S. P. should be used in this preparation; in the presence of a weaker alcohol, the ethyl nitrite rapidly undergoes decomposition; hence the fraudulent dilution of spirit of nitrous ether with water is a very reprehensible practice. Spirit of nitrous ether yields a green color with antipyrine; if it contains any free nitrous acid, it liberates iodine and bromine from their combinations. The presence of traces of nitrous acid may be detected by the blue coloration of guaiac paper. Alkalies, when allowed to remain in contact with the spirit, cause its gradual decomposition.

The proportion of nitrous ether in spirit of nitre cannot be ascertained by means of its specific gravity, for the addition of ethyl nitrite (sp. gr. 0.900) to deodorized alcohol (sp. gr. 0.816), increases the specific gravity of the latter the same as does water.

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* It should be noted that the amount of Sodium Nitrite directed in the formula given by the U. S. Pharmacopœia is too large. It would be correct if Potassium Nitrite had been directed. The proper amount is 635 Gm. The specific gravity of Spirit of Nitrous Ether is nearly 0.820, not 0.836 — 0.842 as given in the earlier issues of the U. S. P.

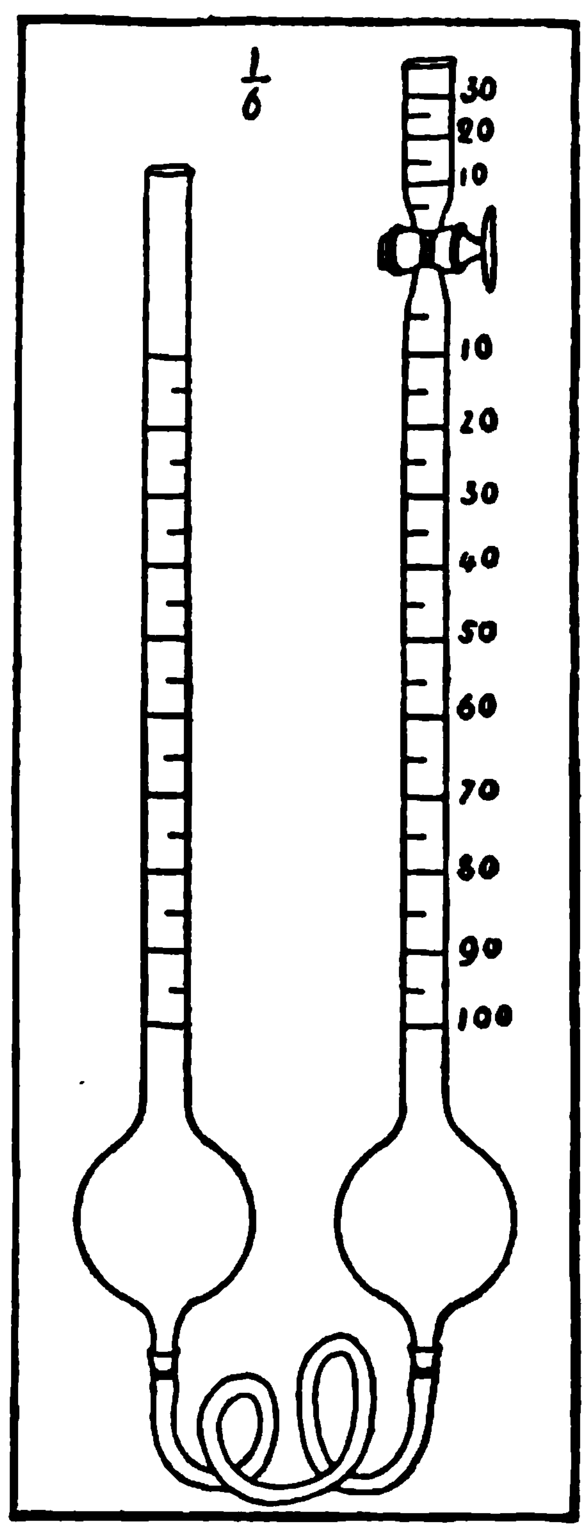
*Assay.**—The process of the Pharmacopœia is that proposed by A. H. Allen, in 1885. It consists in measuring the *volume* of nitrogen dioxide given off by a known volume of the spirit, when decomposed by the addition of potassium iodide and sulphuric acid according to the following equation:—

$C_2H_5NO_2$	+	KI	+	H_2SO_4	=	C_2H_5OH	+	$KHSO_4$	+	I	+	NO
Ethyl Nitrite. 78.87		Potassium Iodide.		Sulphuric Acid.		Alcohol.		Potassium Acid Sulphate.		Iodine.		Nitrogen Dioxide. 29.97

From this it is seen that 78.87 Gm. of ethyl nitrite will yield 29.97 Gm. of nitric oxide, which *measures* under normal pressure at 0° C. (32° F.) 22327 Cc. One gramme of ethyl nitrite will yield at 0° C. 298.249 Cc. of nitric oxide gas, or 1 Cc. of the gas will represent 0.0033529 Gm. of ethyl nitrite.

$$\begin{array}{ccccccc} NO & & C_2H_5NO_2 & & NO & & C_2H_5NO_2 \\ 298.249\text{ Cc.} & : & 1.0 & :: & 1\text{ Cc.} & : & x. \end{array}$$
$$x = 0.0033529.$$

Fig. 327.



Allen's Nitrometer (Curtmann's Modification).

It will be observed that the above figures express the volume of the gas at 0° C. As we cannot carry on the operation at this temperature, we must make an allowance for the difference in volume of gas at higher temperatures. According to the law, gases increase $\frac{1}{273}$ in volume, or 0.003663 Cc. for each degree Centigrade. For example, let us assume that we have obtained 40 Cc. of gas, the temperature being 20° C., and the barometric pressure 740 Mm. It is first necessary to reduce this volume to cubic centimeters expressed at 0° C. This is done by dividing the number of cubic centimeters obtained by 1, plus as many times 0.003663 as there are degrees of temperature; thus we divide 40 by 1.07326 [1 + (20 × 0.003663)], whereby we obtain 37.26 Cc., at 0° C., and at the normal barometric pressure of 760 Mm. (30 inches). If accuracy is desired, we must take the degree of barometric pressure into consideration, for according to Boyle's law, "the temperature remaining the same, the volume of a given quantity of gas is *inversely* as the pressure it bears." Hence we may make the necessary correction by multiplying the volume of gas by the number of millimeters (or inches) of pressure and dividing by 760 (or 30). Thus, in this

* A very exhaustive article on the assay of spirit of nitrous ether was published by Dr. C. O. Curtman in the *Western Druggist* of 1892, p. 244.

example, if the pressure be 740 Mm., the corrected volume would be ($37.26 \times 740 \div 760$) = 36.27 + Cc. If it is desirable to convert this into weight of ethyl nitrite, then we multiply 36.27 Cc. by 0.0033529 (1 Cc. NO = 0.0033529 + Gm. $C_2H_5NO_2$) = 0.12160 + Gm. ethyl nitrite. Therefore 40 Cc. of nitric oxide gas at 20° C., and 740 Mm. measure 36.27 Cc. when reduced to 0° C. and 760 Mm. The assay operation is performed with an instrument called a Nitrometer, of which there are several modifications, that of Curtman's design being preferred by the Pharmacopœia.*

Exercise.—A sample of 5 Cc. of spirit of nitrous ether, when assayed by the U. S. P. process, yielded 50 Cc. of nitric oxide gas, the temperature of the room (and that of the liquid in the nitrometer) being 25° C., and the barometric pressure 750 Mm. How much nitric oxide (NO), by volume will it yield, and also what per cent. by weight will it contain of ethyl nitrite?

50 Cc. $\div$ 1.091575 [1 + (25×0.003663)] = 45.85 Cc. (corrected for temperature).
(45.85 Cc. $\times$ 750 $\div$ 760) = 45.24 Cc. Nitric Oxide (corrected for temperature and pressure.

Hence 5 Cc. of the spirit of nitre yield 9.04 + times its volume (45.24 Cc.) of nitric oxide gas measured at 0° C., and 760 Mm.

45.24 Cc. $\times$ 0.0033529 = 0.151685 + Gm. Ethyl Nitrite.

Spir. Nitre.		Ethyl Nitrite.				
5 Cc. = 4.1 Gm.	:	0.151685	: :	100	:	x

$x = 3.7$ %

Therefore the sample contains 3.7 per cent. by weight of ethyl nitrite.

Exercise.—Were it possible to obtain the theoretical yield with no loss, how much ethyl nitrite could be made from 550 cubic centimeters of deodorized alcohol U. S. P.?

We first ascertain how much 100 per cent. alcohol is contained in 550 Cc. of deodorized alcohol; 550×0.816 (sp. gr.) = 448.8 Gm. by weight; 92.5 per cent. of this = 415.14 Gm. of pure alcohol.

The reaction takes place according to the equation—

C_2H_5OH	+	HNO_2	=	$C_2H_5NO_2$	+	H_2O
Alcohol. 46 p.		Nitrous Acid.		Ethyl Nitrite. 74.8 p.		Water.

As 46 parts of absolute (100 per cent.) alcohol are capable of yielding 74.8 parts of ethyl nitrite, hence 415.14 Gm. of alcohol would yield 675.05 Gm. of ethyl nitrite.

Alcohol.		Ethyl Nitrite.		Alcohol.		Ethyl Nitrite.
46	:	74.8	: :	415.14	:	x

$x = 675.05$

Therefore, if the conditions above stated could be carried out, we would obtain a yield of 675.05 Gm. of ethyl nitrite.

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* The instructions for operating this are given in the U. S. P., part iv, page 509.

SPIRITUS GLONOINI (Liquor Trinitrini B. P.—Spirit of Nitroglycerin—Glonoin—Glyceryl Trinitrate). This contains 1 per cent. by weight of glonoin (glyceryl or propenyl trinitrate) or, as it is more properly known, nitroglycerin. The latter is obtained by the action of a cold mixture of nitric and sulphuric acids on glycerin, the nitro-group (NO_2) replacing three hydroxyls of the glycerin formula; the reaction being

$$\underset{\text{Glycerin.}}{C_3H_5(OH_3)} + \underset{\text{Nitric Acid.}}{3HNO_3} = \underset{\text{Nitroglycerin.}}{C_3H_5(NO_3)_3} + \underset{\text{Water.}}{3H_2O}$$

The sulphuric acid does not take any part in the reaction, except that it serves to abstract the water formed, thereby avoiding the dilution of the nitric acid. Owing to the explosive nature of nitroglycerin, special attention is directed to the precautions given by the Pharmacopœia in regard to the storage and handling of the Spirit, for should any quantity of it be spilled, the alcohol readily evaporates leaving the pure nitroglycerin behind, which readily explodes upon the slightest concussion. In case of an accident of this nature, a solution of caustic potassa or soda should be poured over the spot at once, this causes the rapid decomposition of the nitroglycerin into its harmless constitutents. As a remedy it should be dispensed with caution, being a powerful cardiac stimulant in doses of one to two minims. Caution should be exercised in testing this, since even a small quantity is liable to produce a violent headache.

VINA MEDICATA—(*Medicated Wines*).

MEDICATED WINES are a class of preparations similar to tinctures, only differing as to menstruum, which is, according to the U. S. Pharmacopœia, either a dry, white wine (Vinum Album) or a mixture of white wine with alcohol.

Red Wine (Vinum Rubrum) does not enter into any of the official medicated wines. Since wines themselves readily undergo fermentation when exposed to the air, the medicated wines, which contain additional extractive matter, are still more prone to decomposition, undergoing acetic and mucous fermentation, becoming thereby ropy and sour.

In all instances, in order to enhance the stability of the preparation, the Pharmacopœia has directed the addition of alcohol, either direct, or in the flavoring constituent. Though not as stable as the tinctures, the medicated wines present an advantage in being of a lesser alcoholic strength, hence possessing a lower stimulating effect, which, in the case of the tinctures, often interferes with the action of certain medicinal agents, such as sedatives, expectorants, etc.

The greatest care should be exercised in selecting only the purest wine obtainable, and it should be subjected to the proper tests as specified in the Pharmacopœia. Medicated Wines, owing to their liability to change, should be made up in small quantities only, and kept in well-stoppered bottles, in a cool place.

It is a very important point, in the preparation of medicated wines, to observe that the wine employed be of proper alcoholic strength. With this object in view, the U. S. Pharmacopœia gives a ready method for the estimation of alcohol in wines, which is also applicable to some tinctures and fluid extracts. "Take the specific gravity (to four decimals) of a sufficient portion of the White Wine carefully measured at the temperature of 15.6° C. (60° F.); evaporate the Wine in a tared capsule to one-third of its original weight, cool, and add water until the liquid measures its original volume at 15.6° C. (60° F.); then take the specific gravity (to four decimals) again. The difference between the two specific gravities deducted from 1.0000 corresponds to the specific gravity of an alcohol containing the same percentage of absolute alcohol, by weight or volume, as the Wine under examination, the corresponding percentage being ascertained by referring to the alcoholometric tables." In addition to this, there is another accurate method which is often employed by chemists; this consists in mixing a certain volume (say 50 Cc.) of a wine or fluid containing alcohol with an equal bulk of water (neutralizing any free acid that may be present, by the addition of a little chalk), then distilling carefully until a volume of distillate is obtained, equal to that of the sample of wine or fluid taken (50 Cc. as above). This distillate represents the alcoholic strength of the sample, which is readily ascertained by the determination of its specific

gravity and then finding the corresponding percentage in the alcoholometric tables.

VINA MEDICATA, U. S. P.

Title.	*Active Constituents.**	*Properties.*	*Dose.*
DIRECT SOLUTION.			
Vinum			
Antimonii,	Tartar-Emetic, 0.4 %.	Expectorant,	30–60 ♏.
Ferri Amarum,	Cit. Iron and Quinine, 5 %.	Tonic,	8–15 Cc.
Ferri Citratis,	Cit. Iron and Ammonium, 4 %.	"	8–15 Cc.
Ipecacuanhæ,	Fl'd. Ext. Ipecac. 10 %.	Expectorant,	10–30 ♏.
MACERATION.			
Vinum			
Colchici Seminis,	Colchicum Seed, 15 %.	Diuretic,	30–120 ♏.
Opii,	Powd. Opium, 10 %.	Sedative,	15–20 ♏.
PERCOLATION.			
Vinum			
Colchici Radicis,	Colchicum Root, 40 %.	Diuretic,	10–60 ♏.
Ergotæ,	Ergot, 15 %.	Emmenagogue, Parturient,	3–15 Cc.
NOT MEDICATED.			
Vinum			
Album,	Alcohol, 10–14 %, by weight.	Base.	
Rubrum,	" 10–14 %, "	"	

* See Footnote, page 225.

TINCTURÆ—(*Tinctures*).

Tinkturen, Germ.; *Teintures*, *Alcoolés*, French; *Alcoholados*, Span.

Tinctures are alcoholic or partially alcoholic solutions of the useful constituents of drugs, which are usually not wholly soluble in the menstruum. (Tincture of Iodine, Tinct. of Ferric Chloride, and perhaps a few others are included in this class from long custom).

Menstruum.—The strength of the menstruum employed in different tinctures varies according to the *nature* of the drug. Before a suitable menstruum can be selected, the nature of the active constituents of the drug must be studied, and such a solvent selected as will take up those principles with as little inert matter as possible, and yet yield a permanent and elegant preparation. For this reason, various menstrua are directed by the Pharmacopœia, and unless for a satisfactory reason, a weaker or stronger menstruum than that directed, should not be employed.

The most common menstruum employed is alcohol diluted to different degrees of strength. The alcohol of the U. S. Pharmacopœia is directed to be of the specific gravity 0.820; that of the British 0.838; of the German, 0.830 to 0.834; and of the French, 0.819. In a few instances, the U. S. Pharmacopœia directs the addition of glycerin to the menstruum; this adds to the permanency of tinctures containing tannin-like principles. Such menstrua as aromatic spirit of ammonia and ethereal spirit (ether 7 p., alcohol 3 p.), are also employed, these being known as *ammoniated tinctures* and *ethereal tinctures.**

Strength.—The U. S. Pharmacopœia directs a certain quantity of the air-dried drug, expressed in grammes, to be employed to make 1000 cubic centimeters of the finished tincture.

The British Pharmacopœia directs, on an average, one part (by weight) of the drug to be represented by 8 parts by measure of the finished tincture. In the French, German and Austrian Pharmacopœias, one part of the drug (by weight) is represented by 5 or 10 parts (by weight) of the tincture. The strength of tinctures prepared from potent drugs varies considerably among different foreign Pharmacopœias. It is therefore well to bear this important point in mind in dispensing U. S. Pharmacopœia tinctures in foreign prescriptions.

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* *Teintures éthérées* of the French Pharmacopœia.

TINCTURA.—100 PARTS.	PARTS OF DRUG (DRY).			
	By Weight.			By Measure.
	U. S. P.*	Ph. Ger.	Ph. Fr.	B. P.
Aconiti (leaves),	. .	. .	20	. .
" (root),	35	10	20	12.5
Aloes,	10	. .	20	2.5
Belladonnæ Foliorum,	15	. .	20	5
Cannabis Indicæ (herb),	25	. .	20	. .
" " (extract),	. .	. .	.	5
Cantharidis,	5	10	10	1.25
Cinchonæ,	20	20	20	20
Colchici Seminis,	15	10	20	12.5
Digitalis (Ph. Ger. fresh pulp),	15	8.33	20	12.5
Gelsemii,	15	. .		12.5
Hyoscyami,	15	. .	20	12.5
Iodi,	7	9.1	7.7	2.5
Lobeliæ,	20	20	20	12.5
Nucis Vomicæ (Tr. Strychni),	Ext. 2 Gms.	10	20	Ext. 1½ grs.
Opii,	10	10	13	7.5
Physostigmatis,	15	. .	20	. .
Rhei,	10	10 Aq.	20	10
Stramonii Seminis,	15	. .	. .	12.5
" Foliorum,	. .	. .	20	. .
Veratri (albi),	.	10	20	. .
Veratri Viridis,	40	. .	. .	20

PREPARATION.—For the preparation of tinctures only the *best* obtainable quality of a drug should be employed. The use of cheap and second-rate material is a culpable and reprehensible practice. The market affords an abundance of first-class drugs at a reasonable price for the quality.

The various methods employed in the preparation of tinctures are:—first, Solution; second, Maceration; third, Digestion; fourth, Percolation.

1st. *Solution.*—This is applicable in such instances as tinctures of iodine and tolu, where the material is wholly or practically soluble in alcohol.

2d. *Maceration.*†—This process is preferred by the majority of foreign pharmacopœias. For this purpose large, strong bottles with a wide mouth are selected, the drug (in coarse powder or particles) and menstruum are introduced, and they are then well corked and set aside for a period of from 7 to 14 days. The temperature of the room should be about 20° C.; the bottles should be conveniently placed, so that they may be shaken once or twice daily. At the end of the period of maceration the fluid portion is drained off, the residue then transferred to the strainer, deprived of as much of the fluid as possible by hand pressure, then enclosed securely in the straining-cloth, and subjected to pressure in a tincture press. The tincture is allowed to settle and is then

* This is only approximate for the U. S. P., for the drug is expressed in parts by *weight*, and the finished product in parts by *measure*. In the B. P. the quantity of drug is expressed in avoirdupois ounces and fractions thereof, and the finished product in measure (Imperial pint).

† Concerning the comparative advantages and disadvantages of Maceration and Percolation, see page 189.

filtered. No attempt is made to bring the strained liquid to a definite volume by washing the dregs with menstruum.

3d. *Digestion.*—This is maceration between the temperatures of 30° and 40° C. It is employed in such cases where the drug is difficult of extraction, or where rapid exhaustion is desired. In this operation the drug and menstruum should be placed in a large glass flask, which is placed on a water- or sand-bath. The flask is closed with a perforated stopper, into which may be fitted an inverted condenser (Fig. 151), or a long (4–5 ft.) plain glass tube (air cooler), for the purpose of condensing the volatilized solvent. The apparatus is allowed to become cold before the contents are drained off.

4th. *Percolation.*—While the principle of percolation or displacement has been known and applied in chemical and industrial operations for a very long time, it was first applied, officially, to the preparation of tinctures, fluid extracts, etc., in this country, in the Pharmacopœia of 1840. It is now also recognized to some extent by the pharmacopœias of England, France, Germany, Switzerland, etc.

Percolation as applied to the preparation of tinctures, although demanding care and close attention, is not fraught with the same difficulties as in the preparation of fluid extracts, since the volume of menstruum is largely in excess of that necessary to insure the exhaustion of the drug. This should not, however, lead to carelessness, for no matter how large the excess of menstruum may be, should the operator have packed the drug carelessly, and not have devoted proper attention to the operation, exhaustion cannot be expected. The U. S. Pharmacopœia directs a short period of maceration, previous to beginning percolation. This precaution should always be observed, and the time should rather be lengthened than shortened. The British Pharmacopœia demands a preliminary maceration of forty-eight hours, which is certainly a point in its favor.

The U. S. Pharmacopœia directs that the drug be percolated until a certain volume (1000 Cc.) is obtained. Hence, the menstruum which is retained by the drug is lost. To avoid this, it has been suggested to adopt the method of the British Pharmacopœia. According to this, after the whole of the menstruum (equal in volume to the quantity of tincture to be obtained) has been added, and percolation ceases, the marc is to be transferred to a tincture press, the expressed and filtered liquid mixed with the percolate, and the whole then made up to the proper volume by adding more menstruum.

Some operators attempt to recover the menstruum retained by the drug by forcing it out with water. This is not advisable, since the vegetable tissues, on coming in contact with water, swell and often choke the percolator. Besides, water takes up other principles than alcohol, and since the diffusion of the one into the other cannot be prevented, this diluted menstruum, generally

contaminated with inert extractive, flows into the more or less alcoholic percolate, causing thereby cloudiness or precipitation.*

The practice of preparing tinctures by diluting Fluid Extracts † *should be condemned,* particularly so in the case of potent drugs.

Preservation.—Tinctures should be kept in well-stoppered bottles, away from the direct rays of the sun. As a guide to the estimation of the quality and strength of tinctures, the German Pharmacopœia specifies the limits of specific gravity; the percentage of dry residue left on evaporation on the water-bath; the percentage of ash; or the percentage of acid expressed in milligrammes of KOH, necessary to neutralize 10 Gm. of tincture diluted with 100 Gm. of water. These figures, however, do not give any decisive clue as to the quality of the tincture. When the activity of a drug resides in certain definite proximate principles, the only accurate method of judging the quality of its preparations is by assay. The U. S. Pharmacopœia has thus standardized two of its tinctures, viz., those of Opium and Nux Vomica.

TINCTURÆ HERBARUM RECENTIUM.

This class of preparations was introduced many years ago by Hahnemann, and is extensively used at present in homœopathic and eclectic practice. They were first prepared by the addition of the freshly-expressed juice to twice its weight of alcohol. The United States, as well as French Pharmacopœias, adopted the process of Soubeiran, which consisted in macerating the fresh, cut or bruised drug with alcohol in definite proportions. As a rule, these are very active preparations, for it is justly claimed that the process of drying, in order to prepare drugs for the process of grinding and powdering, injures or alters many sensitive active principles. On the other hand, uniformity in the strength of these preparations cannot be expected, for the freshly-collected drug contains a variable amount of moisture, according to the time of gathering and the length of subsequent exposure. The U. S. Pharmacopœia‡ gives the following directions: "These tinctures, when not otherwise directed, are to be prepared by the following formula: Take of the fresh herb, bruised or crushed, 500 Gm.; alcohol, 1000 Cc.; macerate the herb with the alcohol for fourteen days; then express the liquid and filter." Among the tinctures made by this process and in frequent use are those of Rhus Toxicodendron, Conium, Digitalis, Hyoscyamus, Pulsatilla, Gelsemium, Aconite, Belladonna, etc.

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* See "Recovery of Residual Tinctures from Marcs," R. H. Parker, *Western Druggist*, 1895, p. 51.

† "Tinctures from Fluid Extracts," J. W. England, *Druggists' Circular*, 1893, p. 245.

‡ The French Pharmacopœia directs equal parts of the fresh drug and alcohol of 90 %, and to macerate 10 days.

SUCCI—JUICES.

These are a class of preparations official in the British Pharmacopœia, made by bruising and expressing fresh, succulent drugs. The juice is then mixed with a definite volume of alcohol (1 vol. alcohol to 3 vols. juice), the mixture set aside for seven days, and filtered. These preparations vary in strength for the same reasons which were just given under Tinctures of Fresh Herbs, which latter were introduced into the U. S. Pharmacopœia in lieu of the "Succi."

The British Pharmacopœia recognizes Succus Belladonnæ, Conii, Hyoscyami, Scoparii, and Taraxaci.

EXPLANATORY (TINCTURES).

There are 71 tinctures official in the U. S. Pharmacopœia.

TINCTURA FERRI CHLORIDI.—This preparation should be allowed to stand at least 3 months before being dispensed, as directed by the U. S. Pharmacopœia. By this time it will have developed an agreeable ethereal odor due to the formation of a small amount of ethyl chloride (C_2H_5Cl). Tincture of iron is incompatible with alkalies, alkali earths or carbonates (production of $Fe_2(OH)_6$ or Fe_2O_3); likewise with preparations containing tannic acid (inky mixtures); also with mercurous salts (forming mercuric compounds); with mucilage of acacia it often produces a jelly.

Assay.—See Liquor Ferri Chloridi.

TINCTURA IODI.—Freshly prepared tincture of iodine forms a precipitate upon the addition of water; after long standing, however, it is often found to yield a clear solution with water. This is due to the formation of hydriodic acid produced by the reaction between the iodine and alcohol.

The British Pharmacopœia adds potassium iodide to its tincture for the purpose of rendering it miscible with water. This is not objectionable when it is intended for internal use; but, as it is exceedingly rare to administer iodine in this form, the advantage of the addition of KI is scarcely apparent.

The tincture should be recently prepared. It is incompatible with salts of the metals (forms insoluble metallic iodides); also alkalies, alkali carbonates, ammonium chloride (iodide of nitrogen, explosive), starch (iodide of starch), sodium hyposulphite (decolorized), and most alkaloids.

The so-called Decolorized Tincture of Iodine is made by digesting 10 parts each of iodine, sodium hyposulphite and water, until solution is effected, then adding 16 parts of spirit of ammonia, shaking, adding 75 parts of alcohol, and filtering after three days. The title of the preparation is very misleading, for it does not contain a trace of free iodine, it having all combined with the

alkalies, forming sodium and ammonium iodide, sodium tetrathionate, with some ethyl iodide (C_2H_5I) and triethylamine hydriodide ($N(C_2H_5)_3HI$).

Assay.—The U. S. Pharmacopœia directs that 6.3 Cc. of the tincture be added to a solution of 2 Gm. of potassium iodide in 25 Cc. of water: the alkali iodide is added for the purpose of preventing the precipitation of the iodine in the aqueous liquid. Gelatinized starch is then added, which forms a blue colored solution with the free iodide. To the mixture is now slowly added decinormal solution of sodium hyposulphite,* until the blue color disappears. One molecule of iodine (2 × 126.6 parts) unites with the two molecules of sodium hyposulphite (2 × 247.6 parts) to form the soluble, colorless, sodium iodide, thus:—

$2(Na_2S_2O_3.5H_2O)$	+	$2I$	=	$2NaI$	+	$Na_2S_4O_6$	+	$10H_2O$
Sodium Hyposulphite. 2 × 247.6		Iodine. 2 × 126.6		Sodium Iodide.		Sodium Tetrathionate.		Water.

One molecule Hyposulphite, 247.6 p.		One atom Iodine, 126.6 p.
24.76 Gm. Hyposulphite (1000 Cc.)	=	12.66 Gm. Iodine.
0.02476 " (1 Cc.)	=	0.01266 "
35 Cc. Hyposulphite = 35 × 0 01266	=	0.443 + Gm. Iodine.

Since 6.3 Cc. of tincture were taken, then it must contain of iodine $[(0.443 \div 6.3) \times 100] = 7$ Gm. in 100 Cc.

Tinctura Opii.—The directions of the Pharmacopœia should be strictly adhered to, in the employment of a powdered opium, the morphine strength of which has been previously ascertained by assay. Crude opium (except on a manufacturing scale, and with rigid assay of the product) should never be used, because, from its variable percentage of moisture, it would yield a preparation of a very unreliable strength. The object of the Pharmacopœia is to secure uniformity of strength; any deviation from this, in so important a preparation, is indeed a serious matter.

Assay.—The present official method of assay, for this tincture, is very simple, and no apothecary should excuse himself for not applying it. The process is as follows:—

"If 100 Cc. of Tincture of Opium be assayed by the process immediately following, it should yield from 1.3 to 1.5 Gm. of crystallized morphine.

Assay of Tincture of Opium.

Tincture of Opium, *one hundred cubic centimeters*, ... 100 Cc.
Ammonia Water, *three and five-tenths cubic centimeters*, . . . 3.5 Cc.
Alcohol,
Ether,
Water, each, *a sufficient quantity*.

Evaporate the tincture to about 20 Cc., add about 40 Cc. of water, mix thoroughly, and set the liquid aside for an hour, occasionally stirring, and disintegrating the resinous flakes adhering

*See Decinormal Solution of Sodium Hyposulphite, p. 434.

to the capsule. Then filter, and wash the filter and residue with water, until all soluble matters are extracted, collecting the washings separately."

The tincture should be slowly evaporated in a dish or beaker glass of about 150 Cc. capacity, on a water-bath, and *not boiled.* A higher temperature will result in a partial destruction of the morphine. Before an attempt is made to precipitate the morphine, such impurities as resin and caoutchouc, with as much coloring and extractive matter as possible, should be removed; otherwise these would be carried down with the morphine precipitate, and give false results. Hence the tincture is evaporated to a small bulk (20 Cc.), when the loss of alcohol causes the partial separation of the resin and caoutchouc. This is made more complete by the addition of 40 Cc. of cold water, in which these are comparatively insoluble. After standing the specified time, it should be carefully filtered through a *small* (3 in.) plain filter, the guiding-rod being used to direct the flow of fluid without loss. The residue in the capsule or beaker is rinsed on to the filter and the washing continued until the filtrate comes through devoid of all traces of bitter taste; or better, until a few drops of the filtrate collected on a watch-glass, and acidulated with a drop of dilute hydrochloric acid, ceases to give a precipitate with Mayer's Reagent*; or with Lugol's Solution.

"Evaporate in a tared capsule, first, the washings to a small volume, then add the first filtrate, and evaporate the whole to a weight of 14 Gm. Rotate the concentrated solution about in the capsule until the rings of extract are redissolved, pour the liquid into a tared Erlenmeyer flask, having a capacity of about 100 Cc., and rinse the capsule with a few drops of water at a time, until the entire solution weighs 20 Gm. Then add 10 Gm. (or 12.2 Cc.) of alcohol, shake well, add 25 Cc. of ether, and shake again. Now add the ammonia water from a graduated pipette or burette, stopper the flask with a sound cork, shake it thoroughly during ten minutes, and then set it aside, in a moderately cool place, for at least six hours, or over night."

The weaker solution is first evaporated to a small volume, and the first filtrate, which contains nearly all of the morphine, is then added. In this way the injurious effect of prolonged heat is avoided. After having transferred the entire solution into a tared assay flask, by washing with a little water until the whole weighs 20 Gm., we are ready for the precipitation of the morphine. This alkaloid is in solution, combined chiefly with meconic acid, and inasmuch as morphine is practically insoluble in water (1 in 4350), it may be readily precipitated from its solution by the addition of an alkali, preferably ammonia (since soda or potassa readily dissolves this alkaloid). The ammonia

* Prepared by dissolving 13.546 Gm. of mercuric chloride and 49.8 Gm. of potassium iodide in sufficient distilled water to make 1000 Cc.

water must be of ten per cent. strength, and not more than 3.5 Cc. should be added, for an excess of this, over and above that necessary to combine with the meconic acid present, will cause some of the morphine to be retained in solution. Alcohol and ether are added before the ammonia water; the volume of the former is not sufficient to exert any solvent effect on the morphine, while its presence serves to retain the coloring matter in solution, preventing its being carried down with the morphine. The ether serves to promote the rapid and thorough separation of the morphine as well as to take up coloring matter and narcotine.

"Remove the stopper carefully, and, should any crystals adhere to it, brush them into the flask. Place in a small funnel two rapidly-acting filters, of a diameter of 7 Cm., plainly folded, one within the other (the triple fold of the inner filter being laid against the single side of the outer filter), wet them well with ether, and decant the ethereal solution as completely as possible upon the inner filter. Add 10 Cc. of ether to the contents of the flask, rotate it, and again decant the ethereal layer upon the inner filter. Repeat this operation with another portion of 10 Cc. of ether. Then pour into the filter the liquid in the flask, in portions, in such a way as to transfer the greater portion of the crystals to the filter, and, when this has passed through, transfer the remaining crystals to the filter by washing the flask with several portions of water, using not more than about 10 Cc. in all. Allow the double filter to drain, then apply water to the crystals, drop by drop, until they are practically free from mother-water, and afterwards wash them, drop by drop, from a pipette, with alcohol previously saturated with powdered morphine. When this has passed through, displace the remaining alcohol by ether, using about 10 Cc., or more if necessary. Allow the filter to dry in a moderately warm place, at a temperature not exceeding 60° C. (140° F.) until its weight remains constant, then carefully transfer the crystals to a tared watch-glass and weigh them.

"The weight found represents the amount of crystallized morphine obtained from 100 Cc. of the Tincture."

The filter is first wetted with ether, otherwise, should some of the aqueous filtrate be poured, through carelessness, on the filter, this would prevent the ether from filtering through. After the ether washings have all been decanted upon the filter, the latter is allowed to stand a few minutes until the ether has evaporated, then the aqueous fluid containing the crystals of morphine in suspension is poured, in portions, upon the filter. Crystals always remain adhering to the sides of the flask. These can be easily removed by rinsing out first with a portion of the filtrate, or, if necessary, they may be detached by means of a rubber-tipped glass-rod. The flask is now rinsed out with 10 Cc. of water, used in portions. The U. S. P. directs, that, as soon as the filter has drained, water should be *dropped* (not poured) over the crystals

until they are free from mother liquor; for this purpose not more than about 8 to 10 Cc. of water should be used.* If the crystals are of a light gray or buff color, they will be sufficiently pure, but should they be of a brown, or very dark gray color, then they should be further washed with alcohol saturated with morphine, followed with ether as directed. It is important that the ether follow the morphinated alcohol as soon as the latter has disappeared from the surface of the precipitate on the filter; otherwise, the morphine introduced by the morphinated alcohol might remain in the precipitate, upon evaporation of the alcohol, and the ether would not be able to displace it. The drying is done at a moderate heat, since it is only necessary to remove the ether, when crystallized morphine will remain behind. If heated above the temperature of 60° C., the morphine will lose a portion, or the entire amount of its water of crystallization, yielding lower results. At about 75° C. morphine begins to lose its water of crystallization, and when the temperature is increased to 100° C., it becomes anhydrous.

Tincture of Opium is incompatible with solutions containing free ammonia (aromatic spirit of ammonia), solutions containing tannic acid, and other substances affecting alkaloids.

One grain of powdered opium is represented, in U. S. measures, by 10.5 minims (U. S.), 14 minims (B. P.) 11.3 minims (Ph. Ger.), and 9 minims (Fr. Ph.) of the tincture.

The powdered or dry opium employed by these several Pharmacopœias should contain of morphine, 13 to 15 per cent. of crystallized (U. S.), about 10 per cent. of anhydrous (B. P.), at least 10 to 12 per cent. of anhydrous (Fr. Ph.), and 10 per cent. of anhydrous (Ph. Ger.).

One hundred parts of crystallized morphine correspond to 94.06 parts of anhydrous; and 100 parts of anhydrous correspond to 106.31 parts of crystallized morphine.

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* Water saturated with morphine (morphinated water) may be employed in larger quantities, as it does not exert any solvent action on the morphine.

SYLLABUS OF TINCTURES.

Official Title.	Per Cent.* Active Constituents.	Constituents.	Menstruum.	Dose.
Tinctura—				
Opii Camphorata,	Each 0.4	P. Opium, Benzoic Acid, Camphor, each 4 Gm., Oil Anise 4 Cc.	Dil. Alcohol, Glycerin.	0.5–15 Cc.
Nucis Vomicæ,	2	Ext. Nux Vomica 20 Gm.	Alc. 3 p., Water 1 p.	0.3–1 Cc.
Cantharidis,	5	P. Cantharides 50 Gm.	Alcohol.	0.3–1 Cc.
Capsici,	5	P. Capsicum 50 Gm.	Alc. 95 p., Water 5 p.	0.5–3 Cc.
Moschi,	5	Musk 50 Gm.	Dil. Alcohol.	1-2 Cc.
Strophanthi,	5	P. Strophanthus 50 Gm.	Alc. 65 p., Water 35 p.	0.2-0.6 Cc.
Iodi,	7	Iodine 70 Gm.	Alcohol.	External.
Aloes,	10	Aloes 100 Gm., Liquorice Root 200 Gm.	Dil. Alcohol.	0.3–15 Cc.
Aloes et Myrrhæ,	10	Aloes, 100 Gm., Myrrh 100 Gm., Liquorice Root 100 Gm.	Alc. 75 p., Water 25 p.	2-7 Cc.
Arnicæ Radicis,	10	Arnica Root 100 Gm.	Alc. 65 p., Water 35 p.	External.
Bryoniæ,	10	Bryonia 100 Gm.	Alcohol.	External.
Calumbæ,	10	Calumba 100 Gm.	Alc. 60 p., Water 40 p.	3–14 Cc.
Cardamomi,	10	Cardamon 100 Gm.	Dil. Alcohol.	3–8 Cc.
Catechu Composita,	10	Catechu 100 Gm., Cassia 50 Gm.	Dil. Alcohol.	2-10 Cc.
Chiratæ,	10	Chirata 100 Gm.	Alc. 65 p., Water 35 p.	2–8 Cc.
Cinchonæ Composita,	10	Red Cinchona 100 Gm., Serpentaria 20 Gm., Bitter Orange Peel 80 Gm.	Alc. 85 p., Water 7.5 p., Glycerin.	3–8 Cc.
Cinnamomi,	10	Ceylon Cinnamon 100 Gm.	Alc. 75 p., Water 20 p. Glycerin.	3–15 Cc.
Croci,	10	Saffron 100 Gm.	Dil. Alcohol.	Color.
Gentianæ Composita,	10	Gentian 100 Gm., Bitter Orange Peel 40 Gm., Cardamom 10 Gm.	Alc. 60 p., Water 40 p.	3-8 Cc.
Kino,	10	Kino 100 Gm.	Alc. 65 p., Water 20 p., Glycerin.	2-8 Cc.
Matico,	10	Matico 100 Gm.	Dil. Alcohol.	3–8 Cc.
Opii,	10	P. Opium 100 Gm. (Calc. Phosp.)	Dil. Alcohol.	0.3–0.9 Cc.
Opii Deodorati,	10	P. Opium 100 Gm. (Ether—Calc. Phos.)	Alc. 20 p., Water 80 p.	0.3-0.9 Cc.
Quassiæ,	10	Quassia 100 Gm.	Alc. 35 p., Water 65.	2–4 Cc.
Rhei,	10	Rhubarb 100 Gm., Cardamom 20 Gm.	Alc. 60 p., Water 30 p., Glycerin.	3–15 Cc.
Rhei Dulcis,	10	Rhubarb 100 Gm., Liquorice 40 Gm., Anise 40 Gm., Cardamom 10 Gm.	Alc. 50 p., Water 40 p., Glycerin.	3–8 Cc.
Serpentariæ,	10	Serpentaria 100 Gm.	Alc. 65 p., Water 35 p.	2–8 Cc.
Sumbul,	10	Sumbul 100 Gm.	Alc. 65 p., Water 35 p.	1–4 Cc.
Tolutana,	10	Balsam Tolu 100 Gm.	Alcohol.	Flavor.
Vanillæ,	10	Vanilla 100 Gm., Sugar 200 Gm.	Alc. 65 p., Water 35 p.	Flavor.
Ferri Chloridi,	13.6	Sol. Fe_2Cl_6 250 Cc.	Alcohol.	0.3–1 Cc.
Belladonnæ Foliorum,	15	Belladonna Lvs. 150 Gm.	Dil. Alcohol.	0.3–0.9 Cc.
Cannabis Indicæ,	15	Cannabis Ind. 150 Gm.	Alcohol.	0.3–1 Cc.
Colchici Seminis,	15	Colchicum Seed 150 Gm.	Alc. 60 p., Water 40 p.	0.6–3 Cc.
Digitalis,	15	Digitalis 150 Gm.	Dil. Alcohol.	0.3–1.5 Cc.
Gelsemii,	15	Gelsemium 150 Gm.	Alc. 65 p., Water 35 p.	0.1–0.9 Cc.
Hyoscyami,	15	Hyoscyamus 150 Gm.	Dil. Alcohol.	0.6–3 Cc.

* See Footnote on page 225.

SYLLABUS OF TINCTURES.—*Continued.*

Official Title.	Per Cent.* Active Constituents.	Constituents.	Menstruum.	Dose.
Tinctura—				
	15		Alcohol. [Acid 20 Cc.	0.3–0.6 Cc.
	15		Alc. 60 p., Water 40 p., Acetic	1–2 Cc.
	15		Alc. 75 p., Water 25 p.	0.3–1 Cc.
	15	Gm.	Dil. Alcohol.	0.3–0.6 Cc.
	20		Dil. Alcohol.	External.
	20		Alcohol.	0.5–2 Cc.
	20	0 Gm.	Alc. 60 p., Water 40 p.	Flavor.
	20	'eel 200 Gm.	Alcohol.	Flavor.
Benzoini,	20		Alcohol.	Lotion.
Calendulæ,	20		Alcohol.	External.
Cimicifugæ,	20		Alcohol.	3–7 Cc.
Cinchonæ,	20		Alc. 67.5 p., Water 25 p., Glycerin.	3–7 Cc.
Cubebæ,	20	Cubeb 200 Gm.	Alcohol.	2–7 Cc.
Gallæ,	20	Nutgall 200 Gm.	Alcohol, Glycerin.	Lotion.
Guaiaci,	20	Guaiac 200 Gm.	Alcohol.	1–4 Cc.
" Ammoniata,	20		Sp. Ammonia Arom. *q. s.*	1–4 Cc.
Humuli,	20		Dil. Alcohol.	3–12 Cc.
Hydrastis,	20		Dil. Alcohol.	1–3 Cc.
Ipecacuanhæ et Opii,	20	Cc., Deod. Tr. Opium 1000 Cc.	Dil. Alcohol.	0.3–1 Cc.
Krameriæ,	20		Dil. Alcohol.	2–8 Cc.
Lobeliæ,	20		Dil. Alcohol.	0.5–1 Cc.
Myrrhæ,	30		Alcohol.	1–1.5 Cc.
Pyrethri,	20		Alcohol.	External.
Quillajæ,	20		Alc. 35 p., Water *q. s.*	External.
Rhei Aromatica,	20	Cinnamon, Cloves each 40 Gm., Nutmeg 20 Gm.	Dil. Alcohol, Glycerin.	1.5–10 Cc.
Valerianæ,	20	Valerian 200 Gm.	Alc. 75 p., Water 25 p.	3–8 Cc.
" Ammoniata,	20	Valerian 200 Gm.	Sp. Ammon. Ar. *q. s.*	3–8 Cc.
Zingiberis,	20	Ginger 200 Gm.	Alcohol.	1–3 Cc.
Benzoini Composita,	26	Benzoin 120 Gm., Purif. Aloes 20 Gm., Storax 80 Gm., Balsam Tolu 40 Gm	Alcohol.	Lotion.
Aconiti,	35	Aconite Root 350 Gm.	Alc. 70 p., Water 30 p.	0.06–0.18 Cc.
Veratri Viridis,	40	Veratrum Viride 400 Gm.	Alcohol.	0.06–0.3 Cc.
Cardamomi Composita,	50	Cardamom, Cinnamon each 20 Gm., Caraway 10 Gm., Cochineal 5 Gm.	Dil. Alcohol, Glycerin.	Aromatic.
Lactucarii,	50	Lactucarium 500 Gm. (Benzine).	Dil. Alcohol, Glycerin.	0.5–8 Cc.
Lavandulæ Composita,		Oil Lavender Fl. 8 Cc., Oil Rosemary 2 Cc., Cinnamon 20 Gm., Cloves 5 Gm., Nutmeg 10 Gm., Red Saunders 10 Gm.	Alc. 70 p., Water 25 p., Dil. Alc.	2–7 Cc.

*See Footnote on page 225.

EXTRACTA FLUIDA—(*Fluid Extracts*).

Fluid Extracts are concentrated fluid preparations of nearly uniform strength, representing the activity of the drug, *volume for weight.* When *properly* prepared they afford a permanent, active, concentrated liquid, representing the drug in definite proportions.

As required by the U. S. Pharmacopœia, 1 cubic centimeter of the preparation represents the medicinal activity of 1 gramme of the drug. Previous to 1880, the strength was represented by 1 troy-ounce of the drug to 1 fluidounce of the fluid extract. On comparison it will be seen that our present fluid extracts are about 5 per cent. weaker than those of the Pharmacopœia of 1870, thus:—

100 troy ounces of drug (3110.4 Gm.) yield 100 fluidounces (2956.4 Cc.) of fluid extract.—U. S. P., 1870.
100 grammes of drug yield 100 Cc. of fluid extract.—U. S. P., 1880 and 1890.

It will be seen that according to the U. S. Pharmacopœia of 1870, 3110.4 Gm. (100 troy ounces) of drug yielded 2956.4 Cc. (100 fluidounces) of fluid extract, instead of 3110.4 Cc., as the present Pharmacopœia requires; hence there is a difference of 154 Cc. in the proportion of volume to drug, which render our present fluid extracts about 5 per cent. weaker as compared with those based on troy weight and fluidounces, and which is certainly a point in their favor.

The British Pharmacopœia directs that its liquid extracts (with the exception of those of cinchona, glycyrrhiza, opium and pareira), be made of the strength of 1 avoirdupois ounce to 1 fluidounce imperial. They are practically identical with our own.

The German Pharmacopœia has introduced four fluid extracts, the method of preparation and strength of which is the same as those directed by the U. S. Pharmacopœia.

The U. S. Pharmacopœia directs that all fluid extracts be prepared by the process of percolation, with authority to employ the method of repercolation, if this be found desirable.

Menstruum.—The U. S. Pharmacopœia directs the employment of certain menstrua, which are selected with the view of extracting all the activity of the drug, and at the same time of affording a stable preparation. The different menstrua employed consist of alcohol, various mixtures of alcohol and water, and either of these in conjunction with glycerin. In two instances (triticum and castanea) boiling water is employed to exhaust the drug, with subsequent addition of alcohol, or alcohol and glycerin, to insure the stability of the preparation.

Acetic acid of a strength varying from about 60 per cent. to 20 per cent. or less, has been used by Dr. Squibb as a menstruum for drugs containing ethereal oils, aromatic resins, alkaloids, etc.

It is claimed to yield a very effective and palatable preparation; in experiments with nux vomica and belladonna this menstruum has proven its superiority to alcohol.

Fluid Extracts are prepared by "simple" or "fractional percolation." By "simple" percolation we understand that the entire drug is percolated at one operation; under this head we have the *official process*, that of *vacuum percolation*, and *percolation combined with maceration and pressure.* In "fractional percolation" the drug is divided into two or more portions, the reserved (first) percolate from each portion is set aside, while the subsequent (weaker) percolates are employed for macerating and percolating each subsequent portion. This process is known as that of *repercolation.*

PERCOLATION (*U. S. Pharmacopœia Process*).

The U. S. Pharmacopœia of 1890 directs that all fluid extracts be prepared by the process of percolation. 1000 Gm. of the drug of the proper degree of fineness are moistened, packed, macerated and percolated (see Percolation, page 191), until exhausted. From 700 to 900 Cc. of the *first* portion of the percolate are preserved, and the weaker portion is evaporated at a low temperature (50° C.), to the consistence of a soft extract, which is then dissolved in the reserved portion, to which enough menstruum is finally added to make the finished preparation measure 1000 Cc. The objections to the U. S. Pharmacopœial process of 1870 were that the weak percolate, when evaporated to an ascertained *volume*, sustained a loss of most or all of its alcohol, leaving a more or less aqueous residue, which, when added to the strongly alcoholic reserved portion, caused a precipitation of more or less resinous or other active matter. The operator should be careful not to employ too high a degree of temperature in evaporating the weak percolates, otherwise injury or destruction of organic principles is liable to occur. The official process is often objected to, because of the employment of heat in part of the operation; however it must be remembered that from 75 to 90 per cent. of the activity of the drug is represented by the reserved portion, and that but a very small percentage is subjected to the action of heat, as a rule, which, if properly regulated, will not materially injure the preparation (exceptions are Allium, Prunus Virginiana, etc.).

REPERCOLATION ("*fractional*,"* percolation), as described by Dr. Squibb, its originator (1866), "consists in the successive application of the same percolating menstruum to fresh portions of the substance to be percolated." Its object is the preparation of a fluid extract without the use of heat. The operation may be briefly described thus: 32 parts of the drug in powder are divided into four equal portions of eight parts each, one of which is

* See Prof. Diehl's paper, "Proceed. Am. Phar. Assoc.," 1878, p. 681.

moistened, packed, macerated, then percolated until exhausted, this weaker percolate being received in several distinct portions. The first six parts of the percolate are reserved, and the remaining portions are used successively for moistening and percolating the second eight parts of the powder. Of the second percolate 8 parts are reserved, and the weaker percolate which is again received in several portions, used for the following third portion, as directed above.

The third and fourth fractions of 8 parts each are then treated in the same manner, 8 parts of percolate being reserved from each fraction. Finally, the four reserved portions of $6 + 8 + 8 + 8$ fluidounces are mixed to obtain 30 parts of fluid extract.* The weak percolate remaining over from the last portion of the drug is set aside for a subsequent operation on a fresh lot of the same drug. The National Formulary gives the following directions:—

Fractional Percolation.—Take of the drug, in powder of the prescribed fineness, *sixteen* (16) *troy ounces*, and divide this into three portions, of *eight* (8), *five* (5) and *three* (3) *troy ounces*, respectively.

Moisten the *first portion* (8 troy ounces) with the menstruum and percolate in the usual manner. Set aside the first *three* (3) *fluidounces* of the percolate, and continue until *twenty-four* (24) *fluidounces* more of percolate have passed, which should be received in several portions, so that the more concentrated will be separate from the last, weak percolate.

Then moisten the *second portion* of the drug (5 troy ounces) with the most concentrated of the percolates received during the

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* As a practical example of this operation a typical description of the preparation of a fluid extract, as given by Dr. Squibb, is cited:—

EXTRACTUM CINCHONÆ FLUIDUM—(*Fluid Extract of Cinchona*).

℞	Yellow Cinchona, in powder No. 50, ...	32 parts.
	Stronger Alcohol, s. g. 0.819, 2 parts, ...	For sufficient quantity of menstruum.
	Glycerin, s. g. 1.250, 1 part, ...	
	Water, 2 parts, ...	

Weigh the stronger alcohol, glycerin, and water in succession, in any convenient quantity at a time, into a tared bottle, and mix them thoroughly for a menstruum.

Moisten 8 parts of the cinchona with 8 parts of the menstruum, by thoroughly mixing them, and allow the mixture to stand 8 hours in a closely covered vessel. Then pass the moist powder through a No. 8 sieve, and pack it firmly in a percolator. Pour menstruum on top until the mass is filled with liquid and a stratum remains on top unabsorbed; cover the percolator closely and macerate for 48 hours. Then arrange the percolator for an automatic supply of menstruum, and start the percolation at such a rate as to give 1 part of percolate in about 4 hours. Reserve the first 6 parts of percolate and continue the percolation until the cinchona is exhausted, separating the percolate received after the reserved portion into fractions of about 8 parts each.

Moisten a second portion of 8 parts of the cinchona with 8 parts of the weak percolate—the portion that was obtained next after the reserved percolate—and allow the moist powder to stand for 8 hours in a vessel closely covered. Then pack it moderately in a percolator, and supply the percolator automatically with the remaining fractions of the weak percolate in the order in which they were received, and finally, with fresh menstruum until the cinchona is exhausted. Percolate in the same manner and at the same rate as with the first portion of cinchona, and reserving 8 parts of the first percolate, separate the weaker percolate into fractions of about 8 parts each.

Percolate the third and fourth portions of 8 parts each of the cinchona in the same way as the second portion.

Finally mix the four reserved percolates together to make 30 parts of finished fluid extract; and having corked, labeled, and numbered the bottles containing the fractions of weak percolate, set them away until the process for cinchona is to be resumed.

When this fluid extract is to be again made, repeat the process as with the second portion, and reserve 8 parts of the first percolate as finished fluid extract from each 8 parts of cinchona from that time forward so long as the fractions of weak percolate are carried forward with which to commence each operation.

Upon this small scale the percolate from the first portion should weigh from 3 to 4 times the weight of the powder; and for the repercolations from 5 to 7 times the weight of the powder.

preceding operation after the first 3 fluidounces had passed, and percolate again in the usual manner, using the several reserved percolates, successively, as menstrua. Set aside the first *five* (5) *fluidounces*, and continue the percolation until *ten* (10) *fluidounces* more have passed, which should also be received in several portions.

Finally moisten the *third portion* of the drug (3 troy ounces) with the most concentrated of the last reserved percolates, and proceed as directed for the second portion. Collect the first *eight* (8) *fluidounces* separately, and mix them with the two portions previously set aside so as to make *sixteen* (16) *fluidounces* of Fluid Extract.

This process is adapted for the preparation of solid as well as fluid extracts, but not for other pharmaceutical preparations made by percolation.

This process yields a perfect fluid extract without the use of heat, thereby adapting it to the most sensitive drug. It recommends itself to the apothecary, in that it avoids the loss and expense caused by subsequent concentration; it nearly always insures a perfect preparation, because, though it be indifferently applied, the inaccuracies of one operation are likely to be made up and compensated in others, so that, when the results of the different percolations are mixed together, the general result will be practically uniform.

The only disadvantage the process offers, is that it necessitates the keeping of a series of weak percolates which must be stored away, to be used for the same drug in a subsequent operation.

PERCOLATION AND MACERATION WITH EXPRESSION.

These methods are employed principally by manufacturers on the large scale. The first method consists of a combination of *percolation with expression.* One hundred parts of the drug are moistened, packed, and allowed to macerate several days in a percolator; percolation is then commenced and continued, until 120 parts of menstruum have been added, then when the percolation ceases, the upper stratum, constituting about one-fifth of the drug, is removed and subjected to powerful pressure; the fluid obtained is poured over the balance of the moist drug in the percolator, and when this again ceases to percolate, a second like portion is removed and treated as before; this procedure is continued until the entire amount of drug has been expressed. The reserved percolates are mixed with the fluid obtained from the last expression, making a total of 95 parts of fluid extract.

The second method is simply that of *maceration and expression,* in which the drug is allowed to macerate from 10 to 12 days with about its own weight of menstruum. The maceration is conducted in a tight cylindrical copper vessel, which is inverted at intervals to facilitate the action of the solvent. At the end of the specified time, the drug is removed and subjected to powerful pressure; the marc is returned to the macerator and sufficient

menstruum is added to make up the desired yield. The products of the two expressions, when mixed, constitute the fluid extract.

MACERATION AND PERCOLATION IN VACUO.—As already explained (page 206), the principle underlying this process is this: that, by exhausting the air from the drug, the menstruum is rapidly brought into intimate contact with the cells of the drug, whereby the maceration and exhaustion is expedited. This form of apparatus has been adopted by some of our manufacturers for the preparation of Fluid Extracts. The advantages claimed are that it can be very economically operated, requiring only 16 fluidounces of menstruum for the exhaustion of each pound of drug, besides avoiding much loss of alcohol; and also economizing time.

No class of pharmaceutical preparations has met with so much favor as the fluid extracts. They certainly deserve their popularity, for (if properly prepared) they fully represent all of the active properties of the respective drugs, in a compact form. Aside from this, they present another advantage over the tinctures, namely, this, that owing to their concentrated form, they contain a proportionally much smaller amount of alcohol, the presence of which is a serious objection in such preparations as tincture of conium or of digitalis, for the medicinal action of these drugs is considerably counteracted by the antidotal effects of the excess of the alcohol present.

PRESERVATION.—Fluid Extracts should be kept from the direct rays of the sunlight, and in a room where there is but little variation of temperature. These precautions should be observed so as to avoid changes that may arise from possible precipitation, which, however, cannot be altogether avoided.

The various causes which give rise to precipitates in fluid extracts are, according to the researches of Lloyd:*—

1st. *Oxidation.*—Many vegetable principles are prone to unite with oxygen, forming thereby new and insoluble compounds, which, on being precipitated, carry more or less of the active constituents with them.

Again, an interaction between the plant principles may take place, either gradually or suddenly, with the formation of new or insoluble bodies.

Fluid extracts of astringent drugs, such as geranium, stillingia, cinchona, etc., which contain large amounts of tannates, especially drugs containing red tannates, form, in time, precipitates which are insoluble in all menstrua.

2d. *Change of Solvent Power by Evaporation.*—Medicinal substances are very frequently deposited through a loss of the solvent power of the menstruum, in consequence of the evaporation of alcohol during percolation, or particularly so upon mixing the reserved alcoholic with the evaporated aqueous percolate.

* "Precipitates in Fluid Extracts," Proceed. Am. Phar. Assoc., 1882, p. 509; 1883, p. 336; 1884, p. 410; 1885, p. 411.

3d. *Change of Temperature.*—Through a lowering of the temperature, precipitation results from the inability of the liquid to hold in solution matter which was perfectly soluble in it at a higher temperature. For this reason many manufacturers prefer to prepare their fluid extracts during the winter.

"The fact that the drugs employed are merely air-dry and contain varying amounts of moisture, gives rise to the most important cause of precipitation, namely the change of the alcoholic strength of the menstruum. Some plant powders are very hygroscopic and absorb from 5 to 15 pounds of water per 100, absorbing moisture even in the driest weather. Hence when such drugs are percolated the first part of the percolate contains the water, which is thereby converted into a dilute alcohol, and hence differs from later percolates in alcoholic strength."

This is illustrated by Lloyd in Fluid Extract of Cannabis, which, upon percolation with alcohol, yields a first percolate of reddish-brown color, while the later ones are of deep green color. "The first portions of such percolates contain gum, extractives, and bodies which are more soluble in water than alcohol, while the last portions contain the resins, oils, and such bodies which are more soluble in an alcoholic menstruum; hence, when the several percolates are mixed, a gradual separation of the several dissolved matters takes place."

Still another cause is given by Lloyd, as follows:

"The solvent power of the menstruum varies at different stages of the operation of percolation, aside from that due to the presence of more or less water. . . . Plants contain more or less of gums, gummy extractives, fixed and volatile oils, resins, oleoresins, resinoids, glucosides, tannates, glucose, sugar, chlorophyll, alkaloids, inorganic salts, etc. As the menstruum enters the powder it extracts the matter soluble in that fluid, and this at once forms a *new menstruum*, which has power to dissolve substances which are only partly soluble or insoluble in the original menstruum. Thus, during percolation, a constantly changing menstruum is passing through the powder, although the original menstruum be the same. The percolate is accordingly variable in composition and solvent powers; it may be considered as a collection of percolates and menstrua of different solvent power and varying composition, and hence one fraction of it may react with another, giving rise to precipitation."

The quality, that is, strength of a fluid extract or of any liquid pharmaceutical preparation should never be judged by its color. The amount of solid residue left upon evaporation, or the specific gravity, gives also no reliable criterion; the only sure method of ascertaining the medicinal value of such a preparation is to test its activity physiologically, or *where it is possible*, to make an assay of its active constituents.

CHAPTER XXIX.

SYRUPI—(*Syrups—Sirops—Sirupi*).

Syrups are dense saccharine solutions, generally medicated or flavored.

A dense solution of sugar in water is called *simple syrup.*

When this is impregnated with one or more medicinal substances, it is called a *medicated syrup.*

Simple syrup is employed as a vehicle for the administration of medicinal substances. In order to render it more pleasant and better able to disguise the taste, syrup flavored with aromatic substances is also employed.

The presence of sugar exerts a strong preservative influence upon aqueous extracts of plants, which, without this, would ferment quickly. The preservative action of concentrated solutions of sugar is such, that they do not afford nourishment for micro-organisms, since the sugar withdraws water from these, which is essential to their cell-growth. For this reason, the amount of sugar in the syrup must be adjusted with a view to its preservation. Should the syrup be too concentrated, upon standing, a portion of the sugar is liable to crystallize out, causing thereby a diminution in saccharine strength, giving rise to the same difficulty of fermentation that would take place were the syrup made too weak. For the preparation of simple syrup, the U. S. Pharmacopœia employs about 18.6 parts sugar to 10 parts of water,* the British Pharmacopœia 20 parts to 10, the German Pharmacopœia 15 parts to 10, the French Pharmacopœia 18 parts to 10.† If the solution contains alcohol or much extractive, then a correspondingly smaller amount of sugar must be taken. Only the best refined white sugar should be employed, and this should conform to the U. S. Pharmacopœia requirements of purity.‡ For administration to diabetic patients and application in instances where cane sugar syrup is not admissible, a syrup of saccharine is recommended. This is made by dissolving saccharin 10 parts and sodium bicarbonate 12 parts, in 1000 parts of water.

Preparation.—The method of preparation depends largely upon the nature of the substances employed.

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* Bulk of syrup, resulting from the solution of sugar in water:

Sugar.	*Water.*	*Bulk.*	*Sp. Gr.*
32 ozs. Av.	24 fld. ozs.	45 fld. ozs.	1.273
32 "	20 "	41 "	1.298
32 "	16 "	37 "	1.330
28 "	14 "	30 "	1.317
28 "	16 "	34½ "	1.311
24 "	16 "	32 "	1.290
20 "	16 "	29 "	1.264
16 "	16 "	26½ "	1.231

† Differences of climate partly warrant this difference of concentration.

‡ The so-called rock-candy syrup should not be employed in preparing the official syrups.

1st. The sugar is dissolved in the medicated liquid by a moderate degree of heat (for instance, a water-bath).

2d. The sugar is dissolved in the fluid by a moderate degree of heat, and the solution then raised to the boiling point.

3d. The sugar is dissolved by agitation or by percolation with the cold, medicated solution.

4th. The sugar is added in the form of ready-prepared syrup to the concentrated medicated liquid.

The *hot process* (1st and 2d) is employed in preparing syrups from such solutions of drugs as are not injured by heat. The first method is adapted for preparing such syrups as those of orange or lemon, as the degree of heat is not sufficient to cause any injury to the preparation. The main objection to this process, however, is that it does not yield as clear and bright a syrup as process No. 2. In the preparation of syrups from drugs which are not injured by heat, the second process is preferable. In this the syrup is raised to the boiling point, whereby albuminous matters are coagulated, which are afterwards removed by straining. Syrups which require concentration should be boiled briskly, until they have become sufficiently dense; this may be ascertained by dipping a rod or spatula into the liquid, and noting the viscosity on cooling. The syrup, on cooling, should not form a pellicle or crust upon the surface, which would show that it has been concentrated too far. The object of rapid concentration is to avoid the browning of the syrup, which is caused by the prolonged application of heat. Saccharometers are often employed for this purpose; these enable the operator to control the concentration to a close degree of accuracy.

The *cold process* is best adapted for the preparation of such syrups as those of garlic, almond, orange flowers, etc., as these depend on the presence of sensitive volatile principles for their activity. The sugar is dissolved either by simple agitation or by percolation as directed in the U. S. Pharmacopœia. Syrups prepared according to this method from aqueous extracts of drugs, are very liable to ferment, owing to the presence of albuminous and certain extractive matters. These can be removed only by boiling, which causes their coagulation and precipitation. With this end in view, the Pharmacopœia employs an alcoholic menstruum to exhaust the drug, thus avoiding the extraction of inert matter, while the active principles are retained in solution. In the concentration of these alcoholic solutions, care should be taken that the evaporation be carried on at as low a temperature as possible.

The method of preparing syrups by the addition of fluid extracts to simple syrup, is not under all circumstances advisable. Syrups made in this way usually deposit a sediment in time. The presence of a small amount of alcohol thus added is liable to bring about acetic fermentation of the syrup.

Clarification.—Before the sugar is added, the medicated fluid should be perfectly clear and transparent. Many syrups after being prepared contain particles of finely divided matter in suspension, which interfere with their transparency, hence it is necessary that they be clarified. This may be accomplished by adding paper pulp (prepared from white filter paper) to the syrup, and agitating, or better, by adding it and heating it with the syrup during the process of solution, then filtering through paper of loose texture. The white of eggs (albumen) is also employed for this purpose; it should be beaten with a little water to form a froth, then mixed with the syrup, and the mixture boiled for a short time. The albumen coagulates, forming a scum which rises to the surface, which must be removed by skimming. The syrup is then filtered through paper or flannel.

Preservation.—The fermentation (souring) of syrups is brought about by a variety of causes. One cause is the pouring of a syrup into an unclean or carelessly rinsed bottle. The presence of but a very small amount of old, partly soured syrup, or rinse-water, is sufficient to ruin the most carefully made preparation in a very short time. Syrups which contain too little sugar are very prone to ferment, since, according to reasons already given, weak saccharine liquids afford excellent media for the growth of various microscopic organisms. Those syrups which contain too much sugar, deposit a portion of it on the sides and bottom of the vessel on standing; this causes a diminution in saccharine strength and liability to the same difficulty as above.

Again, pouring hot syrups into bottles and not entirely filling them, favors fermentation, since the ascending aqueous vapors condense above and flow back to the surface, thereby diluting the upper layer of syrup; fermentation once having started, it rapidly extends throughout the entire mass. Bottles should hence be well filled and repeatedly shaken until cold.

The commencement of vinous, or of acetic fermentation is readily noticed by the fluidity and frothiness of the syrup as well as by the odor; the fluidity is caused by the loss of sugar, which has decomposed into carbonic acid (causing the frothing), and alcohol or acetic acid, which are distinguished by their odor.

A most frequent cause of the fermentation of syrups is the introduction of germs from contact with the air; these, as soon as they find conditions favorable, multiply with great rapidity, causing rapid fermentation. The best method of preservation is to pour the strained hot syrup into hot bottles until filled to the rim. Then corks which have been soaked in hot water are forced into the necks of the bottles (displacing a small amount of the syrup) and securely tied with twine. While still hot, the necks of the bottles should be dipped into melted sealing-wax. Since no air can be admitted, the syrups will keep almost indefinitely.

EXPLANATORY.

SYRUPUS ACIDI HYDRIODICI.—The hydriodic acid is developed by the reaction between the potassium iodide and tartaric acid, thus:—

KI	+	$H_2C_4H_4O_6$	=	$KHC_4H_4O_6$	+	HI
Potassium Iodide. 165.5		Tartaric Acid. 149.6		Acid Potassium Tartrate.		Hydriodic Acid. 127.5

The dilute alcohol is employed as solvent for the purpose of assisting the separation of the potassium bitartrate which is insoluble in this menstruum. The potassium hypophosphite * acts here as preservative agent, preventing decomposition of the hydriodic acid, which is caused by the separation of iodine, brought about by the influence of light and air ($2HI + O = H_2O + I_2$). The reaction between the hypophosphite and liberated iodine is as follows:—

KH_2PO_2	+	$4I$	+	$2H_2O$	=	KI	+	H_3PO_4	+	$3HI$
Potassium Hypophosphite.		Iodine.		Water.		Potassium Iodide.		Phosphoric Acid.		Hydriodic Acid.

It is important that the potassium iodide be free from iodate, otherwise subsequent discoloration of the syrup will take place, through liberation of iodine by the action of the acid solution on the iodate in presence of iodide.

This syrup is incompatible with potassium chlorate, mineral acids and salts of the metals; see also Syrupus Ferri Iodidi.

Assay.—In the U. S. Pharmacopœia process of assay 31.88 Gm. of the syrup are first neutralized exactly with ammonia water, whereby ammonium iodide ($HI + NH_3.H_2O = NH_4I + H_2O$) is formed. This is done in order to avoid the liberation of free nitric acid, which would prevent the precipitation of the silver iodide upon the addition of decinormal silver nitrate V. S., thus: $AgNO_3 + HI = AgI + HNO_3$. After neutralization with ammonia the reaction is as follows:—

$AgNO_3$	+	NH_4I	=	AgI	+	NH_4NO_3
Silver Nitrate. 165.5		Ammonium Iodide. $HI = 127.5$		Silver Iodide.		Ammonium Nitrate.

Yellow potassium chromate † is used as indicator, to show the end of the reaction; the silver solution is added until the red color produced ceases to disappear on stirring, leaving the solution of a permanent red tint (silver chromate). The silver will not unite or remain united with the yellow chromate of potassium (indicator) as long as any free hydriodic acid (or NH_4I) is present, but as soon as the last trace of this has been precipitated, then

* It is probable that traces of hypophosphorous acid are also produced:—

$H_2C_4H_4O_6$	+	KH_2PO_2	=	$KHC_4H_4O_6$	+	H_3PO_2
Tartaric Acid.		Potassium Hypophosphite.		Acid Potassium Tartrate.		Hypophosphorous Acid.

† See Decinormal Silver Nitrate Volumetric Solution, page 429.

the next addition of silver solution produces the red silver chromate, at which point we stop.

Since one molecule (169.5 parts) of silver nitrate is equivalent to one molecule (127.5 parts) of hydriodic acid, we have—

$AgNO_3$ Silver Nitrate.		HI Hydriodic Acid.
16.95 Gm. (1000 Cc. $\frac{N}{10}$ V. S.)	=	12.75 Gm.
0.01695 Gm. (1 Cc. $\frac{N}{10}$ V. S.)	=	0.01275 Gm.

25 Cc. = 25 × 0.01275 = 0.3188 Gm. of Hydriodic Acid = 1 per cent. of 31.88 Gm. Or [(0.3188 ÷ 31.88) × 100] = 1 per cent.

Therefore, if 31.88 Gm. of the sample required 25 Cc. of decinormal silver solution under the above conditions, the syrup is of the strength (HI) of 1 per cent.

Exercise.—How much hydriodic acid can be produced from 13 Gm. of potassium iodide?

If, according to the equation (page 278), 165.5 parts of potassium iodide are capable of yielding 127.5 parts of hydriodic acid, then 13 Gm. of potassium iodide will, under the same circumstances, yield 10 + Gm. of hydriodic acid, for

$$\begin{array}{ccccccc} KI & & HI & & KI & & HI \\ 165.5 & : & 127.5 & :: & 13 & : & x \end{array}$$
$$x = 10 + \text{Gm.}$$

Exercise.—How much tartaric acid is necessary to decompose 13 Gm. of potassium iodide into hydriodic acid?

According to the same equation, 149.6 parts of tartaric acid are necessary for the decomposition of 165.5 parts of potassium iodide, hence 13 Gm. of potassium iodide would require 11.7 + Gm. of tartaric acid:—

$$\begin{array}{ccccccc} KI & & H_2C_4H_4O_6 & & KI & & H_2C_4H_4O_6 \\ 165.5 & : & 149.6 & :: & 13\text{ Gm.} & : & x \end{array}$$
$$x = 11.7 + \text{Gm.}$$

The U. S. P. requires 12 Gm. of tartaric acid for this purpose, so there is a slight excess of about 0.3 Gm. above the theoretical amount.

Syrupus Allii (Syrup of Garlic).—The value of garlic depends upon its volatile oil, which consists mainly of allyl disulphide $\left[\begin{array}{c} C_3H_5\text{—}S \\ \quad | \\ C_3H_5\text{—}S \end{array}\right]$ (60 per cent.) and allyl propyl disulphide $\left[\begin{array}{c} C_3H_5\text{—}S \\ \quad | \\ C_3H_7\text{—}S \end{array}\right]$ (7 per cent.); these are very volatile, hence the syrup should be prepared by the *cold* process. The best menstruum for this purpose is diluted acetic acid.

Syrupus Amygdalæ.—This syrup is demulcent and sedative. The latter property is due to the presence of a small amount of hydrocyanic acid, which is formed, together with benzaldehyde (oil of bitter almonds), by the action of water upon the glucoside amygdalin contained in the almonds, under the influence of another

constituent, emulsin, which acts as a ferment, but does not take part in the reaction itself:

$$\underset{\text{Amygdalin.}}{C_{20}H_{27}NO_{11}} + \underset{\text{Water.}}{2H_2O} + \text{Emulsin} = \underset{\text{Glucose.}}{2C_6H_{12}O_6} + \underset{\text{Hydrocyanic Acid.}}{HCN} + \underset{\text{Benzaldehyde.}}{C_6H_5COH} + \text{Emulsin}$$

This syrup is prepared by the *cold* process, to avoid any danger of volatilizing the prussic acid. The same ferment or albuminoid, emulsin, also aids in emulsionizing the fixed oil present in the almonds, when the latter are triturated with water, the result being a milk-like fluid.

SYRUPUS CALCIS (Liquor Calcis Saccharatus, B. P.)—Cane sugar unites with different oxides and hydroxides of the metals to form a class of soluble compounds known as *Saccharates*. This is the case with calcium hydrate, the sugar forming with it at least four different compounds, according to the proportion of the two and the temperature employed ($C_{12}H_{22}O_{11}.xCaO$). When administered, it should be well diluted with water. The syrup should be kept in well-closed vials, since it readily absorbs carbon dioxide from the air.

SYRUPUS FERRI IODIDI.—On bringing iodine and clean, bright iron wire (card teeth) in contact, in presence of water, the following reaction takes place:—

$$(a) \quad \underset{\substack{\text{Iron.}\\55.9}}{Fe} + \underset{\substack{\text{Iodine.}\\2\times126.6}}{2I} = \underset{\substack{\text{Ferrous Iodide.}\\308.9}}{FeI_2}$$

The reaction is known to be complete by the solution assuming a greenish color. Care should be taken that no particles of iodine remain adhering around the sides or neck of the flask, otherwise in pouring off the solution it will become contaminated with free iodine. The resulting syrup should have a bright pea-green color, free from any trace of yellowish cast. The solution on exposure to the air, also the syrup on standing, is prone to become discolored (yellow to brown), due to the separation of free iodine, thus:—

$$(b) \quad \underset{\text{Ferrous Iodide.}}{FeI_2} + \underset{\text{Water.}}{2H_2O} + \underset{\text{Oxygen.}}{O} = \underset{\text{Ferrous Hydrate.}}{Fe(OH)_2} + \underset{\text{Iodine.}}{I} + \underset{\text{Hydriodic Acid.}}{HI}$$

The U. S. Pharmacopœia directs to test for the presence of *free* iodine by the addition of starch paste, which produces a blue color. When in such a condition, the syrup should not be dispensed.

The syrup or solution of ferrous iodide may be kept indefinitely, retaining its pea-green color, if a few pieces of clean iron wire (card teeth) be placed in the bottle, which is to be kept well closed. Should it have become discolored, it is best exposed to the direct sunlight; this causes a re-combination of the free iodine with the iron present.

Syrup of ferrous iodide is incompatible with potassium chlorate, since free iodine is liberated, thus:—

$$(c)\quad 2FeI_2 + KClO_3 = Fe_2O_3 + KCl + 4I$$

Also with salts of the metals, such as those of mercury, lead, silver, etc.; likewise with the inorganic acids.

Assay.—The amount of ferrous iodide present is ascertained by means of decinormal solution of silver nitrate, which reacts according to the following equation:—

$$(d)\quad \underset{\substack{\text{Silver Nitrate.}\\ 2\times 169.5}}{2AgNO_3} + \underset{\substack{\text{Ferrous Iodide.}\\ 308.9}}{FeI_2} = \underset{\text{Silver Iodide.}}{2AgI} + \underset{\text{Ferrous Nitrate.}}{Fe(NO_3)_2}$$

Now, in this case, a measured *excess* of the silver solution is added, and the amount of uncombined silver is ascertained by means of decinormal potassium sulphocyanate V. S.,* ferric ammonium sulphate T. S. being used as indicator.†

1.55 Gm., or, if greater accuracy is required, 1.5447 Gm. of the Syrup are weighed off, and if it be of proper strength, 10 per cent. of this (0.155) should be ferrous iodide. To just precipitate this, 10 Cc. of the silver solution are required, for

(e) $2AgNO_3$ Silver Nitrate.	FeI_2 Ferrous Iodide.
2 × 169.5 p.,	308.9 p.
169.5 p.,	154.4+ p.
16.95 Gm. (1000 Cc. V. S.),	15.44+ Gm.
0.01695 Gm. (1 Cc. V. S.),	0.0544+ Gm.

10 Cc. = 10 × 0.01544 = 0.1544 + Gm. FeI_2.

But, since an *excess* of silver solution over and above what is necessary for the precipitation of the ferrous iodide has been added, this excess is estimated by adding decinormal potassium sulphocyanate V. S., until a red-brown tint remains after shaking. This shows that the sulphocyanate solution has precipitated all of the *free* silver nitrate, and that the slight excess of the sulphocyanate has reacted with the ferric ammonium sulphate, producing a red-brown color (sulphocyanate of iron).

$$(f)\quad \underset{\substack{\text{Potassium}\\ \text{Sulphocyanate.}}}{KSCN} + \underset{\text{Silver Nitrate.}}{AgNO_3} = \underset{\substack{\text{Potassium}\\ \text{Nitrate.}}}{KNO_3} + \underset{\substack{\text{Silver Sulpho-}\\ \text{cyanate.}}}{AgSCN}$$

Potassium Sulphocyanate, 97 p. = Silver Nitrate, 169.5 p.
9.7 Gm. (1000 Cc. V. S.) = 16.95 Gm. (1000 Cc. V. S.)
0.0079 Gm. (1 Cc. V. S.) = 0.01695 Gm. (1 Cc. V. S.)

Thus one cubic centimeter of the sulphocyanate solution is equivalent to one cubic centimeter of the silver solution.

The U. S. Pharmacopœia states that only one cubic centimeter of the sulphocyanate solution should be required, if we had originally added 11 Cc. of the silver solution. Hence, 10 Cc. of this has been consumed by the ferrous iodide, indicating, accord-

* See Decinormal Volumetric Potassium Sulphocyanate Solution, page 431.

† Potassium chromate cannot be used here as indicator, since it reacts with the ferrous salt.

ing to the equation *e*, that the syrup is of proper strength (10 per cent.).

Exercise.—Two grammes of a sample of Syrup of Ferrous Iodide were titrated. First, 12 Cc. of decinormal silver nitrate V. S. were added, and afterward 3 Cc. of decinormal potassium sulphocyanate V. S. were required, until the solution assumed a red-brown color, ferric ammonium sulphate T. S. being used as indicator. What was the strength of the syrup?

Since 1 Cc. of the sulphocyanate V. S. is equivalent to 1 Cc. of the silver V. S., hence 9 Cc. (12 Cc. — 3 Cc. = 9 Cc.) of the silver solution were consumed by the ferrous iodide. Now, since 1 Cc. of decinormal silver nitrate V. S. is equivalent to 0.0154 Gm. of ferrous iodide, hence $9 \times 0.01544 = 0.1389$ Gm.; consequently the 2 Gm. of the syrup contain 0.1389 Gm., or 6.94 + per cent. of ferrous iodide.*

Exercise.—How much ferrous iodide can be obtained from 83 Gm. of iodine?

Since, according to equation *a*, 253.2 parts of iodine yield 308.9 parts of ferrous iodide, 83 Gm. of iodine will yield 101.2 + Gm. of ferrous iodide, for

Iodine.		Ferrous Iodide.		Iodine.		Ferrous Iodide.
253.2	:	308.9	::	83	:	x

$x = 101.3 +$ Gm. ferrous iodide.

Thus 83 Gm. of iodine will yield 101.3 + Gm. of ferrous iodide.

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* In a reaction of this kind the theoretical yield is never obtained, for moisture and impurities in the iodine will lower the results.

TABLE OF U. S. P. SYRUPS CLASSIFIED ACCORDING TO MODE OF PREPARATION.

Title.	*Medicinal Constituents.*	*Properties.*	*Dose.*
Hot Process.			
Syrupus			
Calcis, ...	Calcium Saccharate.	Antacid,	20 ♏.
Picis Liquidæ, . . .	Tar.	Expectorant,	4–8 Cc.
Rubi Idæ, ...	Raspberry Juice.	Vehicle.	
Sarsaparillæ Compositus, ...	Fld. Ext. Sarsaparilla; Fld. Ext. Senna.	Alterative,	15 Cc.
Scillæ, ...	Vinegar of Squill.	Expectorant Diaphoretic.	10–30 ♏.
Syrupus.		Vehicle.	
Tolutanus, ...	Balsam of Tolu.	Vehicle.	
Cold Process.			
Syrupus			
Allii, ...	Garlic.	Stimulant. Expec.,	4 Cc.
Althææ, ...	Marshmallow.	Demulcent.	
Amygdalæ, ...	Almond—HCN.	Demulcent, Sedative.	
Aurantii, ...	Sweet Orange Peel.	Vehicle.	
Aurantii Florum, . .	Orange Flower Water.	Vehicle.	
Calcii Lactophosphatis, ...	Calcium Lactophosphate.	Tonic,	10–15 Cc.
Hypophosphitum, . .	Ca, K, Na, Hypophosphites.	Tonic,	4–8 Cc.
Ipecacuanhæ, . . .	Fld. Ext. Ipecac.	Expectorant,	2–30 ♏.
Lactucarii, ...	Lactucarium.	Hypnotic,	7–10 Cc.
Pruni Virginianæ, . .	Wild Cherry.	Vehicle.	
Scillæ Co, ...	Fld. Ext. Squill; Fld. Ext. Senega; Tartar Emetic.	Expectorant, Diaphoretic.	10–30 ♏.
Senegæ, ...	Fld. Ext. Senega.	Expectorant,	3–8 Cc.
Sennæ, ...	Senna.	Cathartic,	4–15 Cc.
Zingiberis, ...	Fld. Ext. Ginger.	Vehicle.	
Simple Admixture with Syrup.			
Syrupus.			
Acaciæ, ...	Mucilage of Acacia.	Vehicle.	
Acidi Citrici, ...	Citric Acid.	Vehicle.	
Acidi Hydriodici, . .	HI, 1%.	Alterative,	20 ♏.
Ferri Iodidi, ...	Ferrous Iodide, 10%.	Alterative,	10–20 Cc.
Ferri, Quininæ et Strychninæ Phosphatum, ...	Ferric Phosphate, 2%. Quinine Sulphate, 3%. Strychnine, .0.02%.	Tonic,	4 Cc.
Hypophosphitum cum Ferro, ...	Ferrous Lactate, 1% Syrup of Hypophosphites.	Tonic,	4–8 Cc.
Krameriæ, ...	Fld. Ext. Krameria.	Astringent,	2–4 Cc.
Rhei, ...	Fld. Ext. Rhubarb.	Laxative,	4 Cc.
Rhei Aromaticus, . .	Arom. Tr. Rhubarb.	Purgative,	4 Cc.
Rosæ, ...	Fld. Ext. Rose.	Vehicle.	
Rubi, ...	Fld. Ext. Rubus.	Astringent,	4–8 Cc.

MELLITA—(*Honeys*).

The official *Honeys* are a class of thick or semi-liquid, sweet, medicated preparations, differing from syrups in that honey is employed as the vehicle instead of simple syrup.

This class of preparations was formerly quite popular, but their number has been gradually lessened by the various pharmacopœias, until at present Mel Despumatum and Mel Rosæ constitute the only ones remaining. These two are employed simply as bases, or vehicles, for the administration of other remedies.

Great caution should be observed in the selection of honey for pharmaceutical purposes; for, because of its peculiar viscidity, it is easily adulterated with glucose. For the detection of this see U. S. P.

Mel Despumatum. — The U. S. Pharmacopœia directs the strained honey to be clarified by heating it on a water-bath with paper pulp, as long as any scum (consisting of wax and other lighter impurities) rises to the surface. This is removed by skimming. Then, after straining, 5 per cent. of glycerin is added for the purpose of protecting the honey from any change. A more brilliant preparation is obtained if it be filtered through paper* in a steam-jacketed funnel ("Hot Filtration," page 179). Various other clarifying agents are in use and have been suggested, among which are gelatin, white of egg, Irish moss, animal charcoal, aluminum hydroxide, etc.; but all these require that the honey be diluted with water, necessitating therefore subsequent evaporation, which results in impairing the aroma and often the color of the honey.

OXYMELLITA.

These consist of simple or medicated honey mixed with acetic acid.

Oxymel of the British Pharmacopœia consists of a mixture of clarified honey (40 oz.), acetic acid, and water (each 5 fl. oz.). Other pharmacopœias direct that the honey be mixed with dilute acetic acid and evaporated. The simplest process is that of the Ph. Ger. I, which consists in mixing 40 parts of clarified honey with 1 part of acetic acid (sp. gr. 1.040). The most popular preparation of this class is the Oxymel Scillæ, which is made by mixing Vinegar of Squill with clarified honey.

	B. P.	Fr. Ph.	Germ. Ph.
Vinegar of Squill,	1 pt.	1 pt.	1 pt.
Clarified Honey,	1.6 pt.	4 pt.	2 pt.

* For filtering syrups, honey, oils, etc., Schleicher & Schüll's filter paper, Nos. 586 and 584, are especially adapted.

ELIXIRIA—(*Elixirs*).

ELIXIRS are sweetened, aromatic, hydro-alcoholic, medicated preparations.

The word "*elixir*" is derived from the Arabic *iksîr* (itself derived from the Greek), a name applied by alchemists to a wonderful powder capable of transforming base metals into gold and silver. This term was later applied to compound tinctures which were supposed to possess rare medicinal virtues. In modern times, this title was applied in European countries to concentrated alcoholic extracts of drugs usually of disagreeable taste. Later, in American pharmacy, it has been applied to an entirely different class of preparations, characterized by their pleasant aromatic taste and containing from 20 to 25 per cent. of alcohol.

The objection to these preparations is that, owing to the small percentage of medicinal agent present, the dose is necessarily large, the alcohol present often seriously interfering with the medicinal action of the drug.

The U. S. Pharmacopœia recognizes Elixir Aromaticum, which is employed simply as an aromatic flavoring agent, and Elixir Phosphori, each cubic centimeter of which represents 0.00025 Gm. of phosphorus, corresponding to about $\frac{1}{65}$ of a grain in each teaspoonful.

To illustrate their method of preparation the formula for Elixir Aromaticum is quoted.

ELIXIR AROMATICUM, *Aromatic Elixir.*—

Compound Spirit of Orange, twelve cubic centimeters, ...	12 Cc.
Syrup, three hundred and seventy-five cubic centimeters, . . .	375 Cc.
Precipitated Calcium Phosphate, fifteen grammes, ...	15 Gm.
Deodorized Alcohol,	
Distilled Water, each, a sufficient quantity,	
To make one thousand cubic centimeters, ...	1000 Cc.

To the Compound Spirit of Orange add enough Deodorized Alcohol to make *two hundred and fifty* (250) *cubic centimeters*. To this solution add the Syrup in several portions, agitating after each addition, and afterwards add, in the same manner, *three hundred and seventy-five* (375) *cubic centimeters* of Distilled Water. Mix the precipitated Calcium Phosphate intimately with the liquid, and then filter through a wetted filter, returning the first portions of the filtrate until a transparent liquid is obtained. Lastly, wash the filter with a mixture of one (1) volume of Deodorized Alcohol and *three* (3) *volumes* of Distilled Water, until the product measures *one thousand* (1000) *cubic centimeters*."

CHAPTER XXX.

SOLUTIONS (Glycerin as Solvent).

GLYCERITA—(*Glycerites,—Glyceroles,—Glycerins*).

GLYCERITES are solutions of medicinal agents in glycerin.

Glycerin, because of its valuable solvent properties and freedom from rancidity, forms an excellent vehicle for the external application of many organic and inorganic substances. It is adapted as a menstruum in many instances where water or alcohol could not be used. Because of its solvent properties it is added to many preparations in order to prevent subsequent precipitation from taking place.

Glycerin not only effectually protects sensitive compounds from oxidation and change, but also affords permanent elegant solutions which form emollient and soothing applications. Such concentrated solutions as those of carbolic, tannic, and gallic acids, etc., are very convenient, because they readily yield clear solutions on dilution with water. The U. S. Pharmacopœia recognizes 6 glycerites.

GLYCERITA, U. S. P.

Title.	*Constituents.*	*Properties.*
Glyceritum Acidi, Carbolici, ...	Carbolic Acid, 20 Gm. Glycerin, 80 Gm.	Diluted as a Wash.
" Acidi, Tannici, ...	Tannic acid, 20 Gm. Glycerin, 80 Gm.	Local Application, Astringent.
" Amyli, . . .	Starch, Water, each 10 Gm. Glycerin, 80 Gm.	Emollient, Base, and Excipient.
" Boroglycerini,	Boric Acid, 310 Gm. Glycerin to make 1000 Gm.	Antiseptic.
" Hydrastis, . .	Hydrastis, Water (Alcohol). Glycerin.	Diluted, Wash.
" Vitelli, . . . (*Glyconin.*)	Egg Yolk, 45 Gm. Glycerin, 55 Gm.	Local Application.

CHAPTER XXXI.

SOLUTIONS (Oleic Acid as Solvent).

OLEATA—(*Oleates*).

OLEATES are solutions of bases (metallic or alkaloidal) in oleic acid. These preparations as recognized by the Pharmacopœia are *not* definite chemical compounds; they are simply solutions obtained by triturating the medicating substance with a large excess of oleic acid. In the preparation of the oleates, wherever possible, the application of heat should be avoided, since, owing to the reducing properties of the oleic acid, the metallic oxides may be reduced to their metals, which precipitate from solution. As an example of this, the official oleate of mercury, even when prepared in the cold, will on standing deposit more or less metallic mercury. This decomposition will take place more rapidly if heat has been employed in its preparation.

In preparing the oleates of any of the *metals*, only the freshly precipitated, well-dried metallic oxide should be used, on account of the comparatively greater solubility of the freshly prepared oxide. When preparing the oleates of the *alkaloids*, it must be remembered that only the free alkaloids, and not their salts, are soluble in oleic acid. When the free alkaloid is not at hand, it can be readily prepared from any of its salts by dissolving the necessary quantity in water, by aid of a little dilute acid if necessary, then adding slowly, with constant stirring, diluted ammonia water, or another suitable alkali, until it is in slight excess. The precipitated alkaloid is then collected on a plain filter, washed with cold water to remove most of the soluble ammonium or alkali salt present, and dried at 100° C., when it is ready for solution in the oleic acid.

In preparing these oleates, only porcelain or glass utensils should be used, and either glass rods or clean horn spatulas should be used for stirring.

DRY OLEATES.—These dry oleates, or more properly oleopalmitates, are not official; they are definite chemical compounds obtained by interaction between solutions of sodium oleate and metallic salts.

Sodium Oleate may be made by warming 100 parts of oleic acid in a dish to 60° C., then adding a solution of 16 parts of caustic soda in a mixture of 30 parts of alcohol and 90 parts of water, until the acid is neutralized, which is shown by the fact that a faint red tint is imparted to the solution by phenolphtalein.

This soap (sodium oleate) is then dissolved in about 2000 parts

of water, and into it is poured, under constant stirring, a solution of the salt (in molecular proportion) in about 800 parts of water. The resulting precipitate should settle rapidly, leaving a clear, supernatant liquid. Should this not be the case, but the solution remain of a milky appearance, then an insufficient amount of the salt has been added. The reaction takes place according to the following equation:—

$2C_{17}H_{33}COOH$	+	$2NaOH$	=	$2C_{17}H_{33}COONa$	+	$2H_2O$
Oleic Acid. 2×281.3		Sodium Hydrate. 2×40		Sodium Oleate. 2×303.3		Water.

$2C_{17}H_{33}COONa$	+	$Zn(C_2H_3O_2)_2$	=	$\left\{ \begin{matrix} C_{17}H_{33}COO \\ C_{17}H_{33}COO \end{matrix} \right\} Zn$	+	$2NaC_2H_3O_2$
Sodium Oleate. 2×303.3		Zinc Acetate. 182.8.		Zinc Oleate. 625.7		Sodium Acetate.

The following formula may be given for practical use:—

Oleic Acid (sp. gr. 0.890 to 0 900),	100 grains.
Sodium Hydrate,	16 grains or q. s.
Alcohol,	1 fluidrachm.
Zinc Acetate,	550 grains.
Or, Lead Acetate,	675 grains.
Or, Copper Sulphate,	442 grains, etc.

If cold solutions are employed, the oleate will form a light, flocculent precipitate; if the solutions are hot, the oleate will form a soft, sticky mass. If a dry pulverulent oleate is desired, the precipitate obtained under the beforenamed conditions is collected on a strainer and well washed until all traces of the inorganic salt formed in the reaction have been removed; it is then dried by spreading it out on porous tiles or bibulous paper and placing it in a dry place. The oleate obtained by precipitation from a hot solution should be washed by stirring it with hot water, then deprived of water by placing it in a dish on a water-bath and heating. When cold it may be moulded into sticks or pulverized. These oleopalmitates* may be more conveniently made by dissolving 1 part of Castile soap (sodium oleopalmitate) by means of heat in 8 parts of water, allowing to stand 24 hours so as to permit the deposition of the greater portion of sodium palmitate; the clear, supernatant liquid, consisting of sodium oleate, is then decanted off. To this solution is now added, under the same conditions as already mentioned, a slight excess of an aqueous solution of a metallic salt. It should be observed that the saline solution should not contain any free acid, otherwise free palmitic acid will be precipitated. For all practical purposes, an oleate prepared as above directed is sufficiently free from palmitates.†

Oleates are employed in dermal medication, their medicinal properties depending upon the medicinal agent present, their action being influenced by the readiness with which oleic acid solutions are absorbed by the skin.

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* *Druggists' Circular*, 1885, page 2.

† Dr. L. Wolff, *Amer. Jour. Phar.*, 1881, p. 545.

In time, the most carefully prepared oleate of mercury (U. S. P.) will undergo decomposition, with deposition of a portion if not all of its mercury. Hence old samples of this, or even fresh ones which have begun to decompose, should not be dispensed.

The Pharmacopœia recognizes two oleates made from metallic bases, viz., Oleatum Hydrargyri and Zinci, and one made from an alkaloid, viz., Oleatum Veratrinæ.

Exercise.—It is desired to prepare 1 fluidounce of a 25 per cent. solution of Oleate of Quinine, it being assumed that the operator has no free quinine (that is, the alkaloid itself) in stock, but that he has the sulphate.

The first step will be to ascertain how much of the free alkaloid will be needed; thus, 35 per cent. of 410.1 + grains, the weight of one fluidounce of oleic acid (455.7 × 0.900), is 102.5 + grains, the weight of the alkaloid necessary; this is then to be dissolved in 353.2 grains of oleic acid. Owing to the fact that the alkaloid does not occupy the same bulk, weight for weight, as the oleic acid, we would obtain a little less than one fluidounce, hence it is better to prepare a little more (taking, for instance, 500 grains of oleic acid) than necessary, and to throw the slight excess away, or to reserve it for future use. The 102.5 grains of the alkaloid Quinine, which are required for the above-given problem, must be prepared from the Sulphate. Now, if, according to the following equation, 646.6 parts of Quinine correspond to 870.2 parts of the Sulphate, to obtain 102.5 grains of the alkaloid will require 137.9 + grains of the Sulphate.

$$\underset{\substack{\text{Quinine Sulphate.}\\ 870.2.}}{(C_{20}H_{24}N_2O_2)_2H_2SO_4.7H_2O} + \underset{\substack{\text{Ammonia Water.}\\ 2NH_3 = 34.}}{2NH_4OH} = \underset{\substack{\text{Quinine.}\\ 2 \times 323.3}}{2C_{20}H_{24}N_2O_2} + \underset{\substack{\text{Ammonium}\\ \text{Sulphate.}}}{(NH_4)_2SO_4} + \underset{\text{Water.}}{9H_2O}$$

For

$$\underset{\text{Quinine.}}{646.6} : \underset{\text{Quinine Sulphate.}}{870.2} :: \underset{\text{Quinine.}}{102.5} : \underset{\text{Quinine Sulphate.}}{x}$$

$$x = 137.9 +$$

Hence, we would require 137.9 + grains of quinine sulphate and 353.2 grains of oleic acid to prepare a fluidounce (approximately) of a 25 per cent. solution.

CHAPTER XXXII.

ETHEREAL SOLUTIONS.

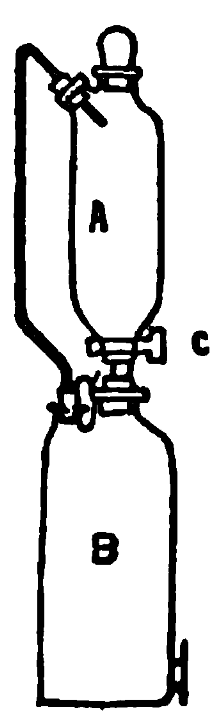
OLEORESINÆ—(*Oleoresins*).

OLEORESINS are ethereal extracts of an oleoresinous nature, obtained from vegetable drugs by percolation with ether.

The drugs selected for this class of preparations are those whose activity resides chiefly in their fixed oil and resin. These constituents are readily extracted from the drug by means of such solvents as ether, chloroform, acetone,* benzin, etc. Among these the Pharmacopœia selects ether as the most suitable. Fluid extracts are also prepared from some of these drugs, but they do not represent the same medicinal properties, since alcohol extracts a different class of principles.

The Pharmacopœia directs that the drug be firmly packed in a suitable percolator for volatile liquids, and that this be provided with a glass stopcock (Fig. 307). In the absence of such an apparatus, any small percolator may be used, and loss through volatilization of menstruum be guarded against by closing the top of the percolator securely by means of a large jar-cork, through which air is admitted by means of a small tube. The perforated cork inserted in the outlet of the percolator should carry a long glass tube which extends into a securely covered receiving bottle, allowance being, of course, made for the escape of air. Rubber should not be used. Another form of percolator adapted to this purpose is shown in Fig. 328. The powdered drug is packed in the percolator, A, and the solvent poured over it. After sufficient maceration, the stopcock, C, is opened sufficiently to allow the proper rate of percolation. The connecting tube is to prevent any loss of volatile solvent, also for the purpose of equalizing the air pressure. It will be seen that the process of percolation demands the handling and use of comparatively large quantities of ether, which, with the subsequent distillation necessary, renders the process more or less dangerous as well as wasteful. These difficulties are readily overcome, when only small quantities of the drug are to be operated upon, by the use of the Soxhlet's Extraction Apparatus (Fig. 329), which permits the complete extraction of the powdered drug with a very small amount of ether. In the flask, A, is placed the necessary volume

FIG. 328.



Percolator for Volatile Solvents.

* G. M. Beringer, *Amer. Jour. Phar.*, p. 145, 1892.

of ether (about 50 Cc.). The powdered drug (about 50 Gm.), E, having been firmly packed into a cartridge of filter paper, is introduced into the Soxhlet tube, D; the latter is in turn connected with the upright condenser, C. The flask, A, is now heated gently on a water-bath, the vapor of the ether rises through B, condenses above and drops on to the powder in the cartridge. After percolating through to the bottom of the tube, D, the solvent charged with the soluble matter of the drug rises in the siphon, F, which, as soon as it becomes sufficiently filled, discharges its contents into the flask, A. This process repeats itself, and is continued until the drug is exhausted, requiring usually from one to two hours. The flask, A, may be connected with a condenser, and the solvent recovered by distillation, or the contents of A may be poured into an evaporating dish and the slight excess of ether allowed to evaporate spontaneously.

FIG. 329.

Soxhlet's Extraction Apparatus.

Commercial oleoresins vary considerably in quality; it therefore behooves the apothecary to prepare his own.

The Pharmacopœia recognizes six oleoresins; specifying in the instance of oleoresin of male fern, that the granular-like deposit (filicic acid) to which the activity is mainly due, should be thoroughly mixed with the liquid portion before use. In oleoresin of cubeb a waxy and crystalline deposit (cubebin) also occurs on standing, but as this has no medicinal value, it should be discarded.

The oleoresins should be administered in diluted form, either in emulsion or pill. Male-fern is best administered in gelatin capsules.

OLEORESINÆ, U. S. P.

	Title.	*Color—Average Yield.*	*Properties.*	*Dose.*
Oleoresina	Aspidii, . . .	Dark-Green, about 16–18%.	Tænicide,	30–60 ♏.
"	Capsici, . . .	Dark Red-Brown, about 17–20%.	Stimulant, Rubefacient.	¼ to 1 ♏.
"	Cubebæ, . . .	Greenish-Brown, about 18–22%.	Diuretic. Expectorant,	5–30 ♏.
"	Lupulini, . .	Reddish Brown; about 55 %.	Tonic, sedative,	2–10 ♏.
"	Piperis, . . .	Greenish-Black, about 6–8%.	Stimulant,	¼ to 1 ♏.
"	Zingiberis, . .	Dark-Brown, about 5%.	Stimulant,	¼ to 1 ♏.

COLLODIA—(*Medicated Collodions*).

The medicated Collodions consist of collodion impregnated with medicinal substances. They are only employed externally.

Collodion, the base of this class of preparations, is prepared by dissolving pyroxylin (soluble gun cotton) in a mixture of 3 parts of ether and 1 part of alcohol. The Pyroxylin is obtained by the action of nitric acid (with assistance of sulphuric acid) upon cotton (cellulose). When nitric acid is caused to react on cellulose ($C_6H_{10}O_5$), various substitution products are formed, according to the strength of the acids employed, being designated as *mono-*, *di-*, and *tri-*nitrocellulose,* etc. Only one of these, the di-nitrocellulose, is completely soluble in the ether-alcohol mixture; this should not be confounded with the explosive hexa- (or tri-) nitrocellulose.

When collodion is applied to a dry surface, the ether and alcohol rapidly evaporate and leave a transparent, adhesive, and contractile film behind. For this reason it forms a valuable application for keeping together the edges of small wounds, or for covering ulcers or abraded surfaces. When it is simply desired to protect the surface, a flexible (non-contracting) film is desirable; for this purpose the official Collodium Flexile should be used.

Collodion is made the vehicle for the application of various remedies, such as iodine, cantharides, corrosive sublimate, etc.

Because of the volatile nature of the ether, the collodions should be kept in well-stoppered vials in a cool place, and because of the extremely inflammable nature of both the pyroxylin and the ether-alcohol, it should not be dispensed or applied in proximity to a light, or fire.

COLLODIA, U. S. P.

Title.	*Constituents.*	*Use.*
Collodium, ...	Pyroxylin, 30 Gm.; Ether, 750 Cc.; Alcohol, 250 Cc.	Protective Application.
Collodium Cantharidatum,	Cantharides, 60 Gm.; Chloroform; Flexible Collodion, 85 Gm.	Blistering Application.
Collodium Flexile, . . .	Collodion, 920 Gm.; Canada Turpentine, 50 Gm.; Castor Oil, 30 Gm.	Protective Application.
Collodium Stypticum, . .	Tannic Acid, 20 Gm.; Alcohol, 5 Cc.; Ether, 25 Cc.; Collodion, to make 100 Cc.	Styptic Application.

* These are compounds in which the nitric acid residue (NO_2) replaces hydroxyl (OH) groups in the cellulose formula. The double formula of cellulose ($C_{12}H_{20}O_{10}$) is taken. Then by the action of nitric acid under different circumstances we obtain,

$C_{12}H_{19}O_9(NO_2)$, ... Mono-nitrocellulose.
$C_{12}H_{18}O_8(NO_2)_2$, ... Di-nitrocellulose, official soluble gun cotton.
$C_{12}H_{17}O_7(NO_2)_3$, ... Tri-nitrocellulose.
$C_{12}H_{14}O_4(NO_2)_6$, ... Hexa-nitrocellulose, explosive gun cotton.

CHAPTER XXXIII.

MIXTURES.

These consist of transparent, or opaque fluids, resulting from the mixing of various liquids, or liquids and solids.

LINIMENTA.

Liniments, according to the Pharmacopœia, are solutions or mixtures of various medicinal substances with alcohol or oleaginous fluids, intended for external application.

When dispensed, they should always be properly labeled as Liniments, or for "External Use."

The U. S. Pharmacopœia recognizes nine liniments, of which three are prepared with a fixed oil as vehicle, *five* with an alcoholic diluent, and *one* with oil of turpentine.

LINIMENTA, U. S. P.

Title.	*Constituents.*	*Vehicle.*
LINIMENTUM.		
Ammoniæ, ... (*Volatile Liniment*).	Ammonia Water, 350 Cc.; Alcohol, 50 Cc.; Cotton Seed Oil, 600 Cc.	Cotton Seed Oil.
Calcis (*Carron Oil*), . .	Solution Lime; Linseed Oil, equal parts.	Linseed Oil.
Camphoræ, ...	Camphor, 200 Gm.; Cotton Seed Oil, 800 Gm.	Cotton Seed Oil.
Belladonnæ, ...	Camphor, 50 Gm.; Fl'd. Ext. Belladonna, to make 1000 Cc.	Fl'd. Ext. Belladonna.
Chloroformi, ...	Chloroform, 300 Cc.; Soap Liniment, 700 Cc.	Soap Liniment.
Saponis, ...	Soap (powd.), 70 Gm.; Camphor 45 Gm.; Oil Rosemary, 10 Cc.; Alcohol, 750 Cc.; Water, to make 1000 Cc.	Diluted Alcohol.
Saponis Mollis, ...	Soft Soap, 650 Gm.; Oil Lavender Flowers, 20 Cc.; Alcohol, 300 Cc.; Water, to make 1000 Cc.	Diluted Alcohol.
Sinapis Compositum. .	Vol. Oil Mustard, 30 Cc.; Fl. Ext. Mezereum, 200 Cc.; Camphor 60 Gm.; Castor Oil 150 Cc.; Alcohol, to make 1000 Cc.	Alcohol.
Terebinthinæ, ...	Resin Cerate, 650 Gm.; Oil Turpentine, 350 Gm.	Oil of Turpentine.

MISTURÆ—(*Mixtures*).

Mixtures, as here understood, are a class of aqueous preparations which contain solid, insoluble substances, in such a condition of subdivision, that, upon agitation, the particles remain for some time in a state of suspension. In three instances the Pharmacopœia directs the intervention of gum arabic or sugar for the purpose of assisting suspension. As exception to the above definition, due to the indiscriminate use of the term, we have two solutions included under this class, viz., Mistura Glycyrrhizæ Composita and Mistura Rhei et Sodæ.

This class of preparations should not be kept on hand any great length of time, since they are prone to ferment.

The U. S. Pharmacopœia recognizes 4 Mixtures.

MISTURÆ, U. S. P.

Title.	*Constituents.*	*Properties.*	*Dose.*
Mistura Cretæ, ... (*Chalk Mixture*).	Comp. Chalk Powder, 200 Gm.; Cinnamon Water, 400 Cc.; Water, sufficient to make 1000 Cc.	Antacid,	15 Cc.
" Ferri Composita, (*Griffith's Mixture*).	Ferrous Sulphate, 6 Gm.; Myrrh, 18 Gm.; Sugar, 18 Gm.; Potassium Carbonate, 8 Gm.; Spirits Lavender, 60 Cc.; Rose Water, sufficient to make 1000 Cc.	Tonic,	30–60 Cc.
" Glycyrrhizæ Composita, ... (*Brown Mixture*).	Ext. Liquorice, pure, 30 Gm.; Syrup, 50 Cc.; Mucilage Acacia, 100 Cc.; Camphorated Tr. Opium, 120 Cc.; Wine of Antimony, 60 Cc.; Spirits of Nitrous Ether, 30 Cc.; Water, sufficient to make 1000 Cc.	Expectorant,	5–30 Cc.
" Rhei et Sodæ, . .	Sodium Bicarbonate, 35 Gm.; Fld. Ext. Rhubarb, 15 Cc.; Fld. Ext. Ipecac, 3 Cc.; Glycerin, 350 Cc.; Spirit of Peppermint, 35 Cc.; Water, sufficient to make 1000 Cc.	Carminative, Laxative,	2–4 Cc. 15–60 Cc.

EMULSA, OR EMULSIONES—(*Emulsions*).

EMULSIONS are artificial mixtures of a milky appearance, which consist of oils, fats or resinous substances suspended in water by the intervention of some viscid, or mucilaginous substance.

The object sought is to break up the substance which is to be emulsified, into as minute particles as possible, enveloping each of these in a coat of the emulsifying agent, which tends to prevent them from reuniting.

Natural Milk, which consists of minute globules of fat (butter) suspended in water by means of the casein present, may be regarded as a sample of a perfect emulsion. The more closely an artificial emulsion can be made to resemble milk, the more permanent will be the product. An emulsion is perfect when the oil globules are invisible to the naked eye. The completeness of emulsification may be judged by placing a sample on a slide under the lens of a microscope, and comparing the size and uniformity of the oil globules of the emulsion with those contained in a sample of milk.

Emulsions may be divided into three classes—the Natural Emulsions, the Gum-Resin and Seed Emulsions, and the Oil or Artificial Emulsions.

1st. NATURAL EMULSIONS.—Such as exist ready formed in nature, as milk, yolk of egg, certain plant juices, etc.

2d. GUM-RESIN AND SEED EMULSIONS.—Such gum-resins as ammoniac, asafœtida, and myrrh, when triturated with water, form emulsions in which the resinous and oily constituents are suspended by means of the gummy matter present. In preparing these emulsions (Emulsa, U. S. P.), the powdered gum-resins should never be employed, since the process of drying and powdering not only destroys the volatile constituents, but also the emulsifying properties of the gum. Selected tears of the gum-resins should be reduced to a coarse powder and then triturated with a small quantity of water, until a smooth paste is obtained, then the balance of water added, and the mixture finally strained. Under this class, the Pharmacopœia recognizes two, viz.: Emulsum Ammoniaci and Emulsum Asafœtidæ.

On triturating such seeds or fruits as the poppy, hemp or almonds with water, an emulsion is obtained in which the oily matter present is suspended (emulsified) by means of the albuminous and gummy matter. Under this class the Pharmacopœia recognizes Emulsum Amygdalæ, in which acacia and sugar are added to enhance the permanency of the preparation.

3d. OIL OR ARTIFICIAL EMULSIONS.—There are a great many different agents and methods by which we can produce artificial emulsions; most general among these, are the two methods known as the *Continental* and *English*.

1st. *The Continental Method.*

This method depends on the formation of a *nucleus* obtained by agitating or triturating together certain quantities, *by weight*, of oil, gum and water. This so-called nucleus being once prepared, it may be diluted with water, in all proportions, without any danger of subsequent separation.

This method rarely fails to produce complete emulsification, if the proper proportions (by weight) of oil, gum, and water be observed, namely:—Oil, 4 parts; pulverized acacia,* 2 parts; water,† 3 parts, for such oils as are difficult to emulsionize, like the class of volatile oils. For the class of fatty oils (cod-liver oil, castor oil, etc.), the proportion of acacia to oil may be reduced to 1 part of gum to 3 to 4 parts of oil. The operation may be carried out in *three* different ways, the first being the most generally employed.

(*a*). The oil is stirred with the powdered acacia in a dry mortar, then the water added at once, the whole being rapidly stirred with the pestle until a thick, creamy emulsion results, which is then diluted as desired. After some experience, this operation may be carried out in a bottle, which must, however, be thoroughly dry before the acacia is introduced. The chief mistake committed by beginners is that they permit the acacia and oil to remain too long in contact, whereby the gum becomes a hard mass, which afterward dissolves only with great difficulty. The two should be stirred or shaken together sufficiently long enough to thoroughly coat each particle of gum with a layer of oil, after which the water should be immediately added.

(*b*). The powdered acacia is triturated with the water until a uniform paste results, then the oil is added at once and triturated rapidly until a thick, creamy emulsion nucleus results.

(*c*). In a mortar place the powdered acacia; in a flask shake a mixture of the oil and water, and pour this over the gum, stirring rapidly until emulsified.

This nucleus should, when properly prepared, present a uniform, creamy appearance; a pearly, translucent appearance assumed by the mixture indicates that an insufficient amount of water or gum is present, and that globules of uncombined oil are floating about. If this is not quickly remedied, the emulsion will "crack," that is, the oil will separate from the aqueous fluid.

2d. *The English Method.*

This method is applied generally to uncertain combinations, and must be followed carefully to insure success. A thick,

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* Coarsely powdered (granulated) acacia should always be preferred for making emulsions, because of its ready solubility, and when triturated with oil or water, it is not liable to form "lumps" like the fine powder; the latter is also open to the objection that it is often found adulterated in the market.

† One and a half times as much water as of gum employed; if more or less gum is used the proportion of water must be increased or decreased in proportion.

smooth mucilage of gum and water is first prepared in a mortar, and to this are added the oil and water, alternately, in small portions at a time, under rapid stirring, so as to break up the oil into globules, which are immediately enveloped by the viscid solution.

Care should be taken in the early stage of the process to add the oil and water very cautiously, until a thick, creamy emulsion is obtained; afterward they may be added more rapidly. A fresh portion of oil should never be added until the former has been thoroughly emulsionized.

It often happens, from too great haste in adding the first portions of oil and water, or by reason of the mucilage not being thick enough, that the emulsion "cracks;" when this is the case, a fresh portion of thick mucilage of acacia should be taken and the mixture re-emulsionized in this by thorough trituration after each addition.

As an example of this method of emulsionizing, the following formula is selected:—

℞.	Copaibæ, ...	f ℨ vj
	Pulv. Acaciæ, ...	ℨ iij
	Aquæ, ... q. s. ad.	f ℥ vj.

Place the Acacia (granulated) in a mortar and triturate with two drachms of water, until a perfectly smooth, thick paste results; then add under constant, rapid stirring, alternately, first a little of the copaiba, then a little water, continuing thus until all of the balsam has been thoroughly emulsified, after which the balance of the water may be added.

In the preparing of an emulsion, such as usually prescribed by physicians, the various ingredients should be mixed in the following order: first, the emulsion nucleus of the oil is prepared; then the flavoring is added, if it be an oil; and this is followed by the syrup and the greater portion of the diluent. Should there be any salts, solid extracts, etc., to be combined, they are dissolved in a little of the reserved diluent and added last with agitation. Should there be small amounts of alcoholic liquids or acid solutions to be added, they should be diluted with a portion of the diluent, and added last, in small portions, the mixture being well agitated after each addition.

OTHER EMULSIFYING AGENTS.

Among the many proposed, the following are the most important:—

Tragacanth forms an excellent emulsifying agent, a much less quantity of it being required than of acacia. For emulsifying the fatty oils, a smooth paste * composed of 1 part of tragacanth and

* Best made by placing 1 part of pulverized tragacanth in a graduate, thoroughly moistening with the same amount of alcohol, then adding the boiling water under constant agitation.

20 parts of water is made, and to this is added at once, with rapid stirring, 20 parts of the oil to be emulsified, and 10 parts of water. For volatile oils (oil of turpentine, cubebs, etc.), the following procedure may be followed: Oil, 8 parts; powdered tragacanth, 1 part, and water 15 parts. To the oil, contained in a *dry* bottle or mortar, add the tragacanth and shake or stir well, then add the water (15 parts), and agitate vigorously. This may be followed by the syrup and remaining diluents, added gradually in portions, the mixture being agitated after each addition.

Yolk of Egg.—This being a perfect natural emulsion, forms an excellent nucleus, yielding a permanent combination. The albumen of the egg should be entirely removed (as its presence is apt to give rise to failure), the yolk is placed in a mortar and rendered perfectly smooth by trituration, then, with a rapid circular motion of the pestle, the oil is added by degrees; should it become too thick, a little water may be added, which is then to be followed by the syrup and the other constituents.

The emulsifying power of *one* fair-sized egg is equivalent to about 10 grammes of gum arabic or 1.25 grammes of tragacanth.

The National Formulary offers the following formula:—

Cod-liver Oil, ...	8 fl. ozs. (other fatty oils may be substituted in place of this).
Glycerite of Yolk of Egg, ...	$2\frac{1}{2}$ fl. ozs.
Syrup of Tolu, ...	2 fl. ozs.
Flavoring, ...	(a sufficient quantity).
Water, enough to make	16 fl. ozs.

"Triturate the glyconin in a mortar with the oil added in small portions at a time, and thoroughly incorporate each portion before adding the next. Then, continuing the trituration, gradually add the syrup of tolu and flavoring. Finally, add enough water to make 16 fluidounces.

Dilute acids, or acid salts, or glycerin may be added to these emulsions without danger of causing them to "crack."

Irish Moss.—For emulsifying oils, this is a successful substitute for acacia; however, it does not effect as fine a subdivision of the oil as the latter, so that upon standing, the oil tends to separate from the mucilage, but this is quickly restored by agitation. This agent answers admirably for emulsifying resinous bodies, since, owing to the viscid nature of its solution, it readily retains them in solution. In using Irish Moss it is necessary first to prepare a clear smooth mucilage. For this purpose 1 part of Irish Moss is washed in cold water to remove the adhering impurities and saline matter, then placed in a capsule or beaker and 40 parts of water added, then heated on a boiling water-bath, for at least 15 minutes, under frequent stirring. The resulting mucilage * is then strained through wetted muslin, and enough water passed through the strainer to make

* Should the mucilage be of a dark-brown color, it may be readily bleached by adding a few cubic centimeters of sulphurous acid, agitating, then placing in a capsule and heating on a water-bath until the odor of the acid has entirely disappeared.

the product weigh 40 parts. Five parts of this mucilage are sufficient to emulsionize 8 parts of oil (fixed). To the mucilage contained in a bottle, add the oil in portions, agitating thoroughly after each addition; follow this up by the syrup, flavoring, and water as may be necessary.

These emulsions are very prone to fermentation; hence, when it is necessary to preserve them for any greater length of time, it is well to introduce about 1 part of alcohol (substituting this for the same volume of water) into each 16 parts of emulsion.

The mucilage of Irish Moss may be preserved by pouring it while hot into bottles, which are filled to the neck, then adding a thin layer of olive or cotton-seed oil, and securely sealing and preserving in a cool place.

Quillaja Bark.—This contains a principle (called saponin), which possesses powerful emulsifying properties, but, owing to the large amount necessary and its expectorant properties, it should not be employed unless by consent of the physician. For preparing emulsions, it is employed in the form of a tincture, which may be made, according to the U. S. Pharmacopœia, by boiling 200 Gm. of the bark, in fine chips, with 800 Cc. of water, washing the residue, boiling the whole liquid down to 600 Cc., then straining, adding 350 Cc. of alcohol, filtering, and adding enough water to the filtrate to make it measure 1000 Cc. One part of the tincture is sufficient to emulsionize 8 parts of fixed oil (cod-liver oil, castor oil, etc.). Volatile oils (oil of turpentine, cubebs, etc.) require their own measure of the tincture.

The valuable feature of Quillaja as an emulsionizing agent lies in the fact that it is utterly indifferent to all substances tending to destroy gum emulsions.

Extract of Malt.—This forms a valuable emulsifying agent for cod-liver oil, for which purpose it is admirably adapted therapeutically. An extract of malt should emulsify its own weight of cod-liver oil. The oil should be gradually added to the extract of malt under constant stirring.

Casein (Saccharated).—In the prototype of a perfect natural emulsion, milk, we find that the fat (butter) is held in suspension by the casein of the milk. The idea of the employment of this casein occurred to M. Léger, of Paris, who proposed a process* for its separation and use. He directs that such substances as resins, balsams, oleoresins, etc., should be first dissolved in a small amount of alcohol. Then for a 100 Cc. mixture, about 8.5 Gm. of saccharated casein, dissolved in an equal weight of water, is added,

* Léger's process is briefly as follows: To 4 liters of milk add 60 Cc. of ammonia water (Ph. Fr., 20 per cent.), shake well, and set aside for twenty-four hours. It will then have separated into two layers, the semi-saponified fat above, and the lacto-serum below. Draw off the lower layer, precipitate the casein by acetic acid, collect the magma on a strainer, and express the liquid. Remove the casein from the strainer, mix it with 10 Gm. of sodium bicarbonate by thorough trituration, and finally add enough sugar to obtain a powder containing, when dry, about 10 per cent. of its weight of casein.

the mixture thoroughly shaken, after which the remaining constituents are added in their proper order with continual shaking. For emulsifying the oils the manipulations are the same as with acacia.

It is claimed for this emulsifying agent that it yields perfect and stable emulsions, which are very palatable and easily tolerated by the most delicate stomach, which cannot be said of gum-arabic emulsions.

Pancreatin, a mixture of natural ferments, is occasionally employed as an emulsifying agent. The emulsions obtained by means of it are rarely permanent, but are often preferred, because of their easy assimilation, for the administration of such fats as cod-liver oil to consumptives. As it is only active in alkaline solution, it should be mixed with an equal bulk of sodium bicarbonate and dissolved in a small quantity of water; to this is then added the oil or emulsion gradually, the mixture being well shaken after each addition.

Gelatin has been proposed (patented) for emulsifying paraffin oils. The patent directs that in 12 parts of a solution of gelatin (4 ounces to the gallon of water), 1 part of phosphate or carbonate of sodium or potassium is to be dissolved. This mixture is capable of emulsifying from 24 to 36 parts of animal or vegetable oils. For emulsifying mineral oils, the alkali is replaced by soft soap.

EMULSIFICATION OF SPECIAL DRUGS.

Salol is melted in a warm mortar and emulsified with powdered acacia, according to the continental method, warm water being employed. On standing, it separates as a fine powder, which is easily reincorporated by agitation.

Jouisse's formula is as follows: Salol and pulverized acacia, each, 4 Gm., tragacanth 0.2 Gm., tincture of tolu 10 Gm., syrup 30 Gm., water, sufficient quantity. The tincture of tolu is added to the water, the mixture strained, and the emulsion made as above directed.

Resins or Resinous Substances (Guaiac, Jalap, Turpentine, etc.) should, if possible, be reduced to a powder and rubbed with one-half their weight of pulverized acacia, with gradual addition of water; or they may be dissolved in a little alcohol and emulsified with yolk of egg, mucilage of chondrus (Irish moss), or tragacanth.

Camphor should be first pulverized by the aid of a little alcohol or ether, then mixed with ten times its weight of gum arabic or with yolk of egg.

Waxes (Spermaceti, Cacao Butter, etc.) are emulsified like the fixed oils, the fat being first melted, then poured into a hot mortar (the pestle being also heated). An equal weight of pulverized acacia is added and the whole thoroughly triturated, then hot water ($1\frac{1}{2}$ times as much as there is of fat) is gradually added under constant stirring.

Lycopodium, or *Lupulin.*—These are rubbed in a mortar until a crumbly mass is obtained, then triturated with an equal weight of acacia, and the water gradually added with trituration.

Balsam Peru.—This may be emulsionized with yolk of egg or acacia. Of the latter, a quantity is taken equal in weight to the amount of balsam used.

NOTES.

Pressure should not be used in preparing emulsions—it is the triturating (agitating) motion that is desired. The motion should be rapid and light. Over-manipulation often causes "cracking."

A rather deep mortar with shallow bottom should be selected for this purpose.

Emulsions of fixed oils should be made with the mortar and pestle, while volatile oils are best emulsified by agitation in a flask or bottle.

When small amounts of oils (croton, cubebs, etc.) or volatile fluids (chloroform, etc.) are to be emulsified, it is best to mix them first with twice their volume of olive or almond oil, which assists in the suspension and imparts a creamy finish to the emulsion.

Alkalies (solution of potassa, solution of lime, borax, etc.) favor the emulsification of fixed oils, but they should never be used, since a combination with the fat-acids takes place with the formation of soap, resulting in the impairment of the therapeutic properties of the oil.

The addition of acids, acid solutions, acid salts, glycerin, alcohol, or alcoholic liquids, generally destroys gum emulsions, chiefly owing to the gum being thrown out of solution. The addition of glycerin, alcohol, or large amounts of salts act physically in abstracting water, thereby rendering the emulsionizing agent less viscid. The addition of borax or tincture of iron will cause an acacia emulsion to become gelatinous on standing. When any of the above incompatibles are ordered in small quantity in an emulsion, they should be added last, in diluted condition, and in small portions at a time, the whole being shaken after each addition. When the amount ordered is large enough to destroy a gum emulsion, recourse may be had to yolk of egg, Irish moss mucilage, or tincture of quillaja.

The Pharmacopœia recognizes four emulsions:

EMULSA, U. S. P.

Title.	*Constituents.*	*Class.*	*Properties.*	*Dose.*
Emulsum Ammoniaci,	Ammoniac, 40 Gm. Water, a sufficient quantity to make 1000 Cc.	Gum-resin Emulsion.	Expectorant,	15–30 Cc.
Emulsum Asafœtidæ,	Asafœtida, 40 Gm. Water, a sufficient quantity to make 1000 Cc.	Gum-resin Emulsion.	Antispasmodic,	15–30 Cc.
Emulsum Amygdalæ,	Sweet Almond, 60 Gm. Acacia p., 10 Gm. Sugar, 30 Gm. Water, a sufficient quantity to make 1000 Cc.	Seed Emulsion.	Demulcent,	60–200 Cc.
Emulsum Chloroformi,	Chloroform, 40 Cc. Expressed Oil of Almond, 60 Cc. Tragacanth, Powdered, 15 Gm. Water, a sufficient quantity to make 1000 Cc.	Oil Emulsion.	Anodyne,	15–20 Cc.

CHAPTER XXXIV.

SOLIDS.

I. FOR INTERNAL USE.

PULVERES—(*Powders*).

Substances which are in a finely subdivided condition are known as powders. Of these we recognize different degrees of fineness; but the *official* powders are of the finest degree of subdivision.

According to the use for which they are intended they may be divided into two classes:—

1st. *Powders for External Use.*—Such powders as are intended for external use, as for dusting * over injured or inflamed surfaces, or for insufflation in the treatment of throat affections, or for blowing into the ear or nostrils, should not be mixed by trituration, as this renders them too compact, depriving them of their necessary lightness. When more than one constituent enters into such a powder, they should, if possible, be separately reduced to a very fine powder, then sifted and mixed with a spatula. Such powders should be dispensed in dry vials.

2d. *Powders for Internal Use.*—Powders intended for internal use may be mixed or triturated in a mortar, as lightness is not the essential feature demanded.

Compound powders, whether they contain potent drugs or not, should be thoroughly and uniformly mixed, for the value of the constituents, and frequently the life of the patient, depends on this precaution. When such substances as extracts, oils, liquids, or hygroscopic salts, such as potassium acetate or citrate, are to be combined into a powder, these should be first triturated with some dry, absorbent powder, then combined with the remainder of the ingredients. Powders which contain hygroscopic substances should not be kept in stock, and when dispensed should be enclosed in waxed paper (paraffin paper).

Powders containing volatile substances, such as camphor, ammonium carbonate, etc., should likewise be dispensed in waxed paper.

In some instances a chemical reaction† is liable to take place, for instance, in mixtures containing potassium chlorate or hypophosphite, and organic substances, such as tannic acid, sulphur, etc. In such cases the powders, separately dried, should be cautiously mixed on smooth paper by the aid of a horn or wooden spatula without friction. In other instances, certain chemicals,

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* *Examples*:—

℞. Lycopodii, ... 90.0
Acidi Salicylici, ... 1.0
Rhizomatis Iridis, ... 9.0

℞. Bismuthi Subcarbonatis, ... 0.008
Pulv. Catechu, ... 0.005
Morphinæ Sulphatis, ... 0.004

℞. Iodoformi, ... 10.0
Cumarini, ... 0.05

† See Incompatibles.

when triturated together, *liquefy*.* *These should be pulverized separately and then mixed without pressure and dispensed in waxed papers;* many of these combinations cannot be dispensed at all without liquefaction; hence the several ingredients should be dispensed separately,

DIVIDING.—It is the habit of many pharmacists to divide all powders by hand, collecting the powder and flattening it out to a rectangular shape, then dividing into the necessary number of equal portions by means of a spatula. This habit of guesswork should not be permitted, particularly if the powder contains a potent drug. *In all cases, where the powder contains an active drug, each portion should be weighed.* In those instances in which the powder is of a harmless nature, accuracy of division may be assisted by mechanical devices.

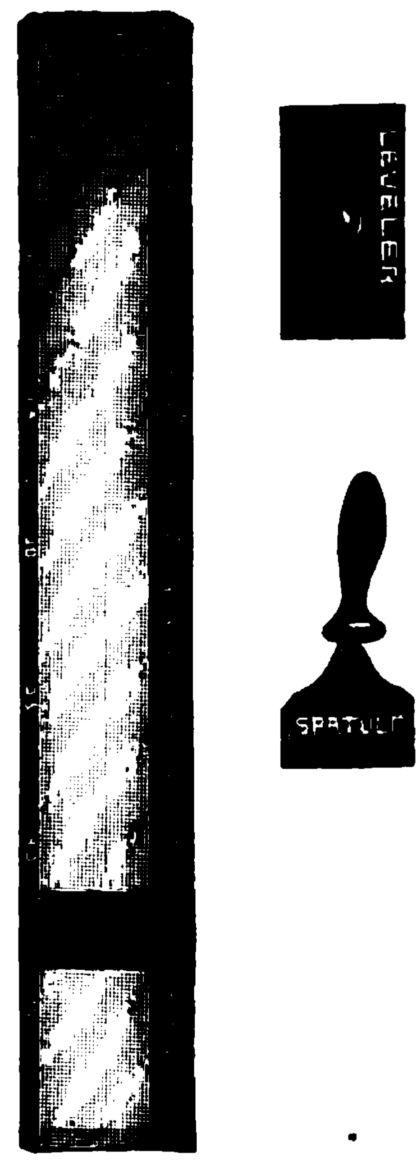
FIG. 330.

Seidlitz Powder Measure.

Fig. 330 illustrates a cup-shaped device, made of hard wood, which is intended for measuring out certain quantities of powders. It is particularly adapted for measuring Seidlitz mixture.

A very convenient device is shown in Fig. 331. This consists of a trough nine inches long, one inch wide, and three-eighths inch deep, closed at one end, and graduated inside. This, together with the leveler and spatula, is made of brass and nickel-plated, the spatula having an ebonized wood handle. The powder is placed in the graduated trough, and the rubber plug placed opposite the graduation denoting the number of powders into which the prescription is to be divided. The powder is then leveled in the trough by means of the leveler, after which the plug is removed, and by use of the spatula in connection with the graduation marks, the powder is accurately divided into the necessary number of parts, each of which is then removed through the open end of the trough.

FIG. 331.



Diamond Powder Divider.

The paper selected for wrapping powders should be of good quality, with a well-calendered or glazed surface. After the required number of powder-papers have been laid out in rows, they should be creased by folding down a narrow margin along one of the longer sides; then after the powder has been distributed upon the several papers, the edge is folded over so as to correspond exactly to the line of the crease; the folded edge is then picked up and turned back toward the operator to such an extent, that a package of a definite and uniform

* For example:—Camphor with Chloral, or Thymol, or Menthol.
Acetate of Lead and Zinc Sulphate.
Antipyrin with Chloral, Naphthol, Piperazin, Sodium Salicylate, etc.

width results. Then the ends of the powder are folded over by means of a spatula, the length being regulated to suit the size of the box in which they are to be placed. In order to secure uniformity in length, the powder-folder may be employed (Figs. 332–4). This is usually constructed so that various lengths may be accurately adjusted.

Nauseous powders are often administered in *wafers.* These consist of thin brittle sheets (square or circular pieces), made by pouring a mixture of flour and water on hot plates. When used, one of these is first dipped into cold water to render it limp. It is then quickly laid upon a tablespoon; the powder is emptied into the center, then the edges are folded over so as to enclose it securely on all sides, water is then poured into the spoon and the whole is swallowed without the least difficulty.

An improvement on this is the "*cachet.*" These are concave discs of wafer, made by dampening and pressing wafer-paper (small discs) between warm moulds. The powder is placed inside, then an empty disc, with its edges moistened, is placed over it and sealed by sufficient pressure. These are dipped into cold water, and swallowed with a draught of cold water.

FIGS. 332, 333, 334.

Powder Folders.

Various forms of elaborate apparatus have been devised for sealing these. Among the simpler ones is the apparatus shown in Fig. 335. The nickel-plated mould (*a*) is so constructed as to hold any size of cachet. One of the halves is placed in the mould, then over the top is placed the "filler" (*b*) to ensure the even filling of the cachet without spilling any of the powder over the edges. Then by means of the holder (*c*) the empty half is picked up, moistened on a piece of wet felt, and, by pressing, joined to the lower half; an automatic spring enables the operator to loosen the sealed cachet.

Fig. 336 illustrates another form in which the cachets are pressed into the circular spaces of plates A and B, then plate C is folded over on to plate B, and, by means of a short funnel, the powders are rapidly deposited in the center of the lower cachets, and if necessary, pressed down and made compact by means of a plunger. When filled, plate C is removed from plate B, then a damping roller is passed over plate A, the edges of the covers being moistened; this is now closed over B with slight pressure,

which seals the cachets, leaving them adhering to the plate A, when opened.

A very convenient substitute for the wafers is the Japanese

FIG. 335.

Apparatus for Filling and Sealing Cachets (Chapereau).

Usego paper. This is thin and strong, the powder is laid in the center of a small disc, the ends are gathered and twisted so as to

FIG. 336.

Cachet Filling and Sealing Apparatus (Konseal).

form a small cylindrical package, which is then dipped in water and swallowed. The paper is digested with the medicine.

GELATIN CAPSULES.

The gelatin capsule affords a convenient method of administering nauseous powders and liquids.

Capsules are designated as *hard* and *soft*.

FIG. 337.

Capsule Moulds.

They are made by dipping smooth olive-shaped moulds into a hot solution of gelatin,* allowing the coating to set and then removing. The moulds consist of olive-shaped solid heads (*c*) of polished bone, ivory, or metal, fixed upon rods (*b*) of wood, or metal, which are placed upright in perforations in a slab of wood (Fig. 337), in the back of which a handle is fixed. The moulds (olives) with the neck of the supporting rod are slightly oiled by means of a piece of cloth, secured in the base, then the frame is grasped by the handle, and the tips immersed a few seconds in the gelatin solution, which is kept at a uniform temperature (about 40° C.). On removing the moulds, the excess of solution is allowed to run off, then the moulds are rotated so as to distribute the film evenly on all sides; as soon as the mass has set sufficiently, they are put aside until cold and firm enough for removal. A knife is passed round the shank of the mould, close to the bulb, so as to separate that portion adhering to the handle. Then, by grasping the capsule lightly between two fingers it is gently removed, and placed in supports (*d*) for drying.

The soft capsules are filled by means of a syringe with a long-pointed tip, or by means of a pipette. Care must be taken that no fluid of an oily nature be allowed to drop on the upper edge of the capsule.† Then by means of a camel's-hair brush, or glass rod, the open end of the capsule is sealed over with a portion of the melted composition. These soft gelatin capsules are useful for the administration of such liquids as Terebene, Oil of Turpentine, Creosote, Apiol, etc.; they are made of various shapes, as ovoid, globular—flattened, round. The small, round (hard) capsules are known as gelatin "pearls."

Elastic, or soft, empty capsules can be obtained in the market, being ovoid in shape, elastic, and filled with air. They are placed

	Hard Capsules.		*Soft Capsules.*
* Gelatin,	6 pts.,		25 pts.
Acacia,	1 pt.,	Glycerin,	10 pts.
P. Sugar,	1 pt.,		8 pts.
Water,	5 pts.,		45 pts.

Steep the gelatin in water, when soft add the gum and sugar, and heat in a covered vessel on a water-bath until dissolved.

† Should this occur the oil may be removed with alcohol.

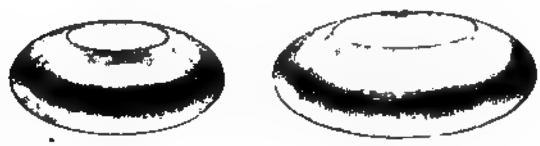
on a stick perforated with holes, the elongated tops removed with a scissors, then filled with a pipette, or syringe, and sealed.

The empty, hard gelatin capsules, Fig. 340, are of cylindrical shape, their capacity being indicated by various numbers. They should be filled with the powder in *dry* condition and not in mass form. They may be filled by grasping the longer half between the fingers, and by pressing downward with a slight rotary motion over the powder; for this purpose the powder should be heaped; after the capsules are filled, the tops are slid over as far as possible.

FIG. 338.

Globular and Ovoid Gelatin Capsules.

FIG. 339.



Elastic Gelatin Capsules.

FIG. 340.

Gelatin Capsules (Empty).

Care should be taken to keep the fingers dry and clean, and after filling, to carefully wipe any adhering powder from the surface of the capsule.

It is, however, preferable to employ the capsule filler, which is far more cleanly and accurate.

There are several forms of these in the market, among which the following may be recommended for their simplicity:—

FIG. 341.

Davenport Capsule Filler.

The Davenport Capsule Filler, Fig. 341, consists of a funnel of light metal (plated) with a very wide rim, flattened on one side, the tube of which is short and of a size adapted to fit the size of capsule for which it is intended. A plunger is provided for the purpose of forcing the powder compactly into the capsule.

The Raymond Capsule Filler, Fig. 342, consists of two blocks of hard wood, in the lower one of which sockets are bored sufficiently

Fig. 342.

Raymond Capsule Filler.

Fig. 343.

Acme Capsule Filler.

deep to accommodate the capsules to one-half of their length. The upper block is pierced with corresponding funnel-shaped holes;

this, when placed over the lower block, encloses the capsules securely. The powders are emptied into the funnel-shaped apertures and forced down by means of a wooden plunger. The upper block is then removed and the tops of the capsules slid over the filled, lower portions.

The Acme Capsule Filler, Fig. 343, consists of a block of wood, with perforations for holding a dozen capsules. This block slides back and forward in a metallic case, on one end of whose upper side is placed a funnel, through which, by means of a plunger, the powder is readily introduced into the capsules.

The U. S. Pharmacopœia recognizes 9 compound powders.

PULVERES, U. S. P.

Title.	*Constituents.*	*Properties.*	*Dose.*
PULVIS			
Antimonialis, ...	Antimony Oxide, 33 Gm. Ppt. Calcium Phosph., 67 Gm.	Diaphoretic, Emetic,	0.2–0.5 Gm.
Aromaticus, ...	P. Cinnamon, 35 Gm.; P. Ginger, 35 Gm.; P. Cardamom, 15 Gm.; P. Nutmeg, 15 Gm.	Aromatic.	
Cretæ Compositus, .	Prep. Chalk, 30 Gm.; Acacia, 20 Gm.; Sugar, 50 Gm.	Antacid,	1–4 Gm.
Effervescens Compositus (Seidlitz Powder), .	Sodium Bicarb., 31 Gm.; Rochelle Salt, 93 Gm.; Tartaric Acid, 27 Gm.	Laxative.	
Glycyrrhizæ Compositus,	P. Senna, 180 Gm.; P. Liquorice, 236 Gm.; Washed Sulphur, 80 Gm.; Oil Fennel, 4 Gm.; Sugar, 500 Gm.	Laxative,	2–8 Gm.
Ipecacuanhæ et Opii (Dover's Powder), .	P. Ipecac, 10 Gm.; P. Opium, 10 Gm.; Sugar of Milk, 80 Gm.	Diaphoretic,	0.3–1 Gm.
Jalapæ Compositus, . .	P. Jalap, 35 Gm.; Potass. Bitart., 65 Gm.	Cathartic,	1–4 Gm.
Morphinæ Compositus (Tully's Powder), . .	Morphia Sulphate, 1 Gm.; P. Camphor, 19 Gm.; P. Liquorice, 20 Gm.; Ppt. Calc. Carb., 20 Gm.	Diaphoretic,	0.3–0.9 Gm.
Rhei Compositus, . . .	P. Rhubarb, 25 Gm.; Magnesia, 65 Gm.; P. Ginger, 10 Gm.	Laxative, Antacid,	0.3–12 Gm.

TRITURATIONES—(*Triturations*).

These are a class of powders which contain active substances in a minute state of subdivision, obtained by trituration with sugar of milk. By means of these we can accurately regulate the doses of powerful substances.

In the preparation of these powders it is advisable to employ the sugar of milk in small crystals or coarse powder, so that

during the process of trituration, which is necessary to bring it to a fine powder, the medicinal ingredient may at the same time receive thorough and uniform subdivision.

The following general formula is given by the U. S. Pharmacopœia:—

"Unless otherwise directed, Triturations are to be prepared by the following formula:—

Take of

The Substance, *ten grammes*,	10 Gm.
Sugar of Milk, in moderately fine powder, *ninety grammes*	90 Gm.
To make *one hundred grammes*,	100 Gm.

Weigh the substance and the sugar of milk separately; then place the substance, previously reduced, if necessary, to a moderately fine powder, in a mortar; add about an equal measure of sugar of milk, mix well by means of a spatula, and triturate them thoroughly together. Then add fresh portions of the sugar of milk, from time to time, until the whole is added, and continue the trituration until the substance is intimately mixed with the sugar of milk and reduced to a fine powder."

TRITURATIO ELATERINI (*Trituration of Elaterin*).

Elaterin, *ten grammes*,	10 Gm.
Sugar of Milk, in moderately fine powder, *ninety grammes*,	90 Gm.
To make *one hundred grammes*,	100 Gm.

Mix them thoroughly by trituration."

ELÆOSACCHARA—OLEOSACCHARA (N.F.)—(*Oleosaccharates*).

Oleosaccharates, or oil-sugars consist of sugar flavored with volatile oil or some other volatile aromatic substance.

The German Pharmacopœia directs that 1 gramme of volatile oil be added to 50 grammes of sugar in moderately fine powder, and the mixture thoroughly triturated. In France, oleosaccharates are made double this strength. The oleosaccharate of vanilla is prepared from 1 part of finely cut vanilla and 9 parts of crystallized sugar (rock candy), triturated until a fine powder results; in place of the vanilla bean, a mixture of vanillin and cumarin is often employed.

Under the title of Oleosacchara, the National Formulary directs the following general formula:

Volatile Oil,	1 drop.
Sugar,	30 grains.

Triturate the sugar with the volatile oil to a fine powder.

The oleosaccharates are intended as a pleasant aromatic vehicle for administering medicinal substances in powder form. Those prepared from volatile oils should be freshly made when wanted for use. Only the best quality* of fresh volatile oil should be employed.

* Old resinified oils impart a bitter, unpleasant taste, as well as terebinthinate odor, to the sugar.

MASSES RESULTING FROM ADMIXTURE OF POWDERS WITH FLUIDS.

CONFECTIONES—(*Confections*).

Confections (conficio = to make up) are soft masses resulting from the admixture of one or more medicinal substances with sugar. They are usually prepared by incorporating the drug or drugs in paste or powder form with some saccharine liquid.

This is a very ancient method of administering medicines, but it has almost gone out of use at present.

The *Conserve* (conservo = to keep) differs from the above in that sugar is added to the fresh drug beaten to a pulp, in sufficient quantity to form a soft mass; the sugar serving as a preservative agent as well as a vehicle.

The *Electuary** is a mixture of powders with pulps, syrup, or honey. It is of a softer consistence than the confections as understood by the Pharmacopœia. But it should not be too soft, so as to deposit the ingredients on standing.

Confections, when they have become hard from drying out, may be restored to a pulpy condition by working them over with a little glycerin. The U. S. Pharmacopœia recognizes Confectio Rosæ, which is employed as a vehicle for massing pills and administering other remedies, and Confectio Sennæ, which is employed as a cathartic.

Confectio Rosæ.	Red Rose, powdered,	80 Gm.
	Sugar, powdered,	640 "
	Clarified Honey,	120 "
	Stronger Rose Water,	160 Cc.

Confectio Sennæ.	Senna, powdered,	100 Gm.
	Cassia Fistula,	160 "
	Tamarind,	100 "
	Prune,	70 "
	Fig,	120 "
	Sugar,	555 "
	Oil of Coriander,	5 "
	Water, sufficient to make	1000 Gm.

MASSÆ.

The U. S. Pharmacopœia recognizes three pill masses. They are permanent preparations and are conveniently kept in stock.

Massa Copaibæ. (Dose 0.5 to 2 Gm.)	Copaiba,	94 Gm.
	Magnesia,	6 "
	Water, a sufficient quantity.	

On mixing copaiba with magnesia it gradually loses its fluidity,

* Having as vehicle, honey or syrup, pulp of prunes or tamarinds. The German Pharmacopœia directs the following proportions to be observed:—

For 1 part of powd. drug,	3 to 5 p. of Honey or Syrup.
" 1 " " "	4 to 6 p. Prune or Tamarind Pulp.
" 1 " difficultly soluble salt	1 p. of Syrup.
" 1 " " " "	2 p. of Pulp.

and finally becomes hard and brittle. This is due to the chemical combination of the magnesia with the copaibic acid (hard resin). The length of time required for this combination to take place varies with the condition of the copaiba. For this combination of the copaibic acid and magnesia it is essential that a certain amount of water be present. As there is rarely sufficient in the magnesia, it is generally added.

Massa Ferri Carbonatis (*Vallet's Mass*). (Dose: 0.2 to 0.5 Gm.)	**Ferrous Sulphate,**	**100 Gm.**
	Sodium Carbonate,	**100 "**
	Clarified Honey,	**38 "**
	Sugar,	**25 "**
	Syrup and Water, of each sufficient to make	**1000 Gm.**

Syrup is added to the ferrous sulphate solution and the wash water, to protect the ferrous salt against the absorption of oxygen. Boiling distilled water is employed to avoid the oxidizing action of the air, which is contained in the unboiled water. The reaction which takes place between the ferrous sulphate and sodium carbonate, results in the formation of the greenish-gray colored ferrous carbonate ($FeCO_3$). This readily undergoes oxidation; hence it is necessary to carry on the washing as rapidly as possible, and to protect the ferrous carbonate by employing boiled water and syrup. The product is finally made into a mass with honey and sugar. This contains about 42 per cent. of Ferrous Carbonate, and is probably the most efficient form for the administration of iron.

Massa Hydrargyri (*Blue Mass or Pill*). (Dose: 0.2 to 0.5 Gm.)	**Mercury,**	**33 Gm.**
	Glycyrrhiza, powdered,	**5 "**
	Althæa, powdered,	**25 "**
	Glycerin,	**3 "**
	Honey of Rose,	**34 "**
		100 Gm.

This contains one-third of its weight of mercury. The mass can be prepared on a small scale by the pharmacist, but care must be taken that the extinguishment of the mercury is carried on until the globules are no longer visible through a lens magnifying at least ten diameters. Among the various agents that may be employed for the extinguishment of the mercury in this instance, the Confection of Rose is one of the best, as it is not only effective, but also protects the mercury quite well from oxidation. However, upon long standing, both mercurous and mercuric oxide are apt to form, owing to the slow oxidation of the finely subdivided mercury. As these are toxic when present in any quantity, it is necessary that the sample be tested for their presence as directed by the Pharmacopœia.

TROCHISCI—(*Troches*).

TABELLÆ—PASTILLI.

Troches (lozenges) are round or oval, solid, flattened masses, consisting of medicinal substances combined with sugar and mucilage.

They represent a convenient form of administering such remedies as are intended to act by continual application, through slow disintegration, on the throat. Troches generally vary in weight from one-half to one gramme. According to their method of preparation, they may be divided into two classes.

1st. THOSE MADE BY COMPRESSION.—In this case the medicinal constituents are mixed with powdered sugar, then moistened with some kind of mucilage, granulated and compressed into tablet form, as described under compressed tablets (page 335).

FIG. 344.

Troches (various forms).

2d. THOSE MADE BY MOULDING.—A mass is prepared, and after rolling it out to the desired thickness, the lozenges are cut out by means of moulds, or the mass is made into pills and reduced to the desired size and shape by compression.

In preparing a mass, the one or more medicinal constituents, in a finely powdered condition, are thoroughly mixed with a finely powdered diluent (sugar),* then made into a mass by the careful addition of mucilage of tragacanth. In some instances the Pharmacopœia directs the use of powdered tragacanth, and that the mass be made up by the addition of water. Great care must be exercised when proceeding by the latter method, to add the water cautiously, while the mass is being thoroughly worked, otherwise it is likely to become too soft for moulding.

* Confectioners' sugar.

The manufacturer employs machinery for kneading the masses, while the apothecary relies upon the mortar and pestle. For this purpose the pill-pestle, as shown in Fig. 351, is best adapted. After the mass has been prepared, which should be of a consistence slightly softer than that of a pill-mass, it is rolled out upon a lozenge-board (Fig. 345), the thickness of the mass being made uniform, and regulated by a frame along the sides of the board upon which the ends of the roller rest. The surface of the mass is dusted with a mixture of powdered sugar and starch, and then divided into lozenges by means of a punch. These punches are made of various sizes and shapes, to suit the taste of the operator. They may consist of a hollow cylinder of tin or steel, or more elaborately constructed, as shown in the form illustrated in Fig. 346. This consists of a hollow cylinder, inside of which, by means of the handle, *g i*, the plunger, *d*, is operated; the screw, *a*,

FIG. 345.

Rolling out Mass for Troches.

regulates the distance to which the plunger may recede, thereby controlling the thickness of the lozenge. This plunger, *d*, may consist of a die which stamps a letter or design on the lozenge in the operation of cutting; on pressing the arm, *g*, at *i*, the rod at *d* is forced downward and discharges the lozenge.

After being moulded or cut, the lozenges are placed on trays and allowed to dry in a moderately heated drying room.

In the absence of a lozenge punch, the mass may be rolled out into a cylinder, cut and formed into pills, which, when pressed with a spatula, may be made to yield a lozenge of any desired thickness, the edges of which may be rounded by rotating between the blades of two spatulas. Should the edges of a

lozenge, thus made, become ragged or crack, this generally indicates that the mass is too dry. It should then be returned to the mortar and worked over with the addition of a little tragacanth mucilage.

Aside from sugar and tragacanth, extract of liquorice is often employed as a base. This can be medicated as desired, and owing

FIG. 346.

Troche Cutter.

to its plasticity, can be readily formed into a variety of shapes, as shown in Figs. 347, 348. When the mass is rolled out into a thin cylindrical rod (3 to 4 Mm. diameter) and cut into pieces of about 10 to 12 Mm. in length, these little cylinders are designated "*bacilli*" or "*sticklets.*"

FIG. 347.

Ovoids.

FIG. 348.

Mouth Pastilles.

The following mixture may also be employed as a base; 1 part of chocolate (grated), 2 parts of powdered sugar, and 0.05 parts (for 30 Gm. of mass 0.5 Gm.) of powdered tragacanth.

Currant paste is also employed as a basis for this purpose.

The U. S. Pharmacopœia recognizes 15 formulas for troches.

Title.	*Constituents—100 Troches.*	*Active Constituent, to each troche.*
TROCHISCI		
Acidi Tannici, ...	Tannic Acid, 6 Gm.; Sugar, powd., 65 Gm.; Tragacanth, powd., 2 Gm.; Stronger Orange Flower Water, a sufficient quantity.	Tannic Acid, 0.06 Gm.
Ammonii Chloridi, . .	Ammonium Chloride, 10 Gm.; Extract of Liquorice, 25 Gm.; Tragacanth, powd., 2 Gm.; Sugar, powd., 50 Gm.; Syrup of Tolu, a sufficient quantity.	Ammonium Chloride, 0.1 Gm.
Catechu, ...	Catechu, 6 Gm.; Sugar, powd., 65 Gm.; Tragacanth, 2 Gm.; Stronger Orange Flower Water, a sufficient quantity.	Catechu, 0.06 Gm.
Cretæ, ...	Prepared Chalk, 25 Gm.; Acacia, 7 Gm.; Spirit of Nutmeg. 3 Cc.; Sugar, powd., 40 Gm.; Water, a sufficient quantity.	Prepared Chalk, 0.25 Gm.
Cubebæ, ...	Oleoresin of Cubeb, 4 Gm.; Oil of Sassafras, 1 Cc.; Extract of Liquorice, 25 Gm.; Acacia, powd., 12 Gm.; Syrup of Tolu, a sufficient quantity.	Oleoresin Cubeb, 0.04 Gm.
Ferri, ...	Ferric Hydrate, 30 Gm.; Vanilla, cut, 1 Gm.; Sugar, powd., 100 Gm.; Mucilage of Tragacanth, a sufficient quantity.	Ferric Hydrate, 0.3 Gm.
Glycyrrhizæ et Opii, . .	Extract of Liquorice, 15 Gm.; Powd. Opium, 0.5 Gm.: Acacia, powd., 12 Gm.; Sugar, powd., 20 Gm.; Oil of Anise, 0.2 Cc.; Water, a sufficient quantity.	P. Opium, 0.005 Gm.
Ipecacuanhæ, ...	Ipecac., powd., 2 Gm.; Tragacanth, powd., 2 Gm.; Sugar, powd., 65 Gm.; Syrup of Orange, a sufficient quantity.	P. Ipecac, 0.02 Gm
Krameriæ, ...	Extract of Krameria, 6 Gm.; Sugar, powd., 65 Gm.; Tragacanth, powd., 2 Gm.; Stronger Orange Flower Water, a sufficient quantity.	Ext. Krameria, 0.06 Gm.
Menthæ Piperitæ, . . .	Oil of Peppermint, 1 Cc.; Sugar, powd., 80 Gm.; Mucilage of Tragacanth, a sufficient quantity.	Oil of Peppermint, 0.01 Cc.
Morphinæ, et Ipecacuanhæ, ...	Morphine Sulphate, 0.16 Gm.; Ipecac, powd., 0.5 Gm.; Sugar, powd., 65.00 Gm.; Oil of Wintergreen, 0.2 Cc.; Mucilage of Tragacanth, a sufficient quantity.	Morphine Sulphate, 0.0016 Gm.; P. Ipecac, 0.005 Gm.
Potassii Chloratis, . . .	Potassium Chlorate. 30 Gm.; Sugar, powd., 120 Gm.; Tragacanth, powd., 6 Gm.; Spirit of Lemon, 1 Cc.; Water, a sufficient quantity.	Potassium Chlorate, 0.3 Gm.

Title.	Constituents—100 Troches.	Active Constituent, to each troche.
Santonini, ...	Santonin, 3 Gm.; Sugar, powd., 110 Gm.; Tragacanth, powd., 3 Gm., Stronger Orange Flower Water, a sufficient quantity.	Santonin, 0.03 Gm.
Sodii Bicarbonatis, . .	Sodium Bicarbonate, 20 Gm.; Sugar, powd., 60 Gm.; Nutmeg, bruised, 1 Gm.; Mucilage of Tragacanth, a sufficient quantity.	Sodium Bicarbonate, 0.2 Gm.
Zingiberis, ...	Tinct. Ginger, 20 Cc.; Tragacanth, powd., 4 Gm.; Sugar, powd., 130 Gm.; Syrup of Ginger, a sufficient quantity.	Tincture of Ginger, 0.02 Cc.

PILULÆ—(*Pills*).

PILLS are spherical or elongated masses of medicinal substances of such a size as to be convenient for swallowing. The pill forms a very convenient method of administering such substances as are characterized by an unpleasant odor or taste.

The weight * of pills varies from 0.1 to 0.3 Gm. for vegetable powders, and up to 0.6 Gm. for inorganic combinations; a pill which is much larger than this is known as a *bolus*.

Very small coated pills are called *granules*.

A pill-mass should be sufficiently plastic to admit moulding, and yet sufficiently firm to enable the pills, when moulded, to retain their shape.

To be successful in the preparation of pill-masses, a knowledge of the *nature* of the substances to be combined is necessary, for, with systematic procedure, the most intractable substances can be managed.

Pills should not be made too firm or hard, which would render them insoluble in the stomach, causing thereby nausea and irritation.

The pill-mass consists essentially of two parts, viz., *the active ingredients*, whether solid or liquid, and the *excipient*, which imparts the proper degree of consistence and tenacity.

Some substances are of such a plastic nature as to render the addition of an excipient unnecessary, as, for instance, the soft extracts; others, like gum-resins or resins, when dry, possess no adhesiveness, yet acquire this property on addition of a little solvent, such as alcohol; such powders as extract of liquorice or some of the powdered extracts only require the addition of water to impart adhesiveness; thus, in many instances we *develop*, and do not impart adhesiveness.

When the solid (as camphor, inorganic salts, etc.) does not

* The size, as compared to the weight of pills, varies according to the *nature* of the substance, some being very light and bulky, while others are heavy and compact.

possess adhesiveness, we *impart* it by the addition of an excipient which has these qualities.

Such substances as are in a fluid or semi-fluid condition should be incorporated with inert and absorbent powders, as liquorice root or powdered marshmallow; if the amount of fluid be such as to render the pill too large, it should be first evaporated until the residue has the consistence of a soft extract.

Pills containing deliquescent substances should be coated immediately after their preparation.

Inorganic salts which contain water of crystallization should be first dried before being combined into a pill-mass.

Powders, when non-adhesive, should be combined with a soft extract or some adhesive excipient; the indiscriminate use of large quantities of powdered acacia or tragacanth is to be condemned, since they render pills very hard and quite insoluble. When used as excipient they should be combined with a little glycerin.

Active or potent substances, such as corrosive sublimate, arsenous acid, alkaloids, etc., which are administered in very small doses, should be intimately mixed with some inert powder (sugar of milk, etc.) by trituration, then incorporated into a mass.

Care should be taken not to combine substances which react with one another, as, for instance, acid salts and carbonates, silver salts or permanganates with organic matter, etc.

The hands and all utensils employed should be kept scrupulously clean.

The first precaution in making up the pill-mass is to observe that all constituents have been reduced to a very fine powder and thoroughly mixed. Then, if an excipient is necessary, one should be selected which will least increase the size of the pill, and only enough added to yield a uniform and plastic mass.

Under all circumstances the mass should be thoroughly worked, so as to secure a perfect and uniform distribution of the medicinal constituents. When the operator is uncertain as to the amount of excipient necessary, it is best to proceed by adding small quantities at a time until the desired degree of plasticity is obtained, the mass being rapidly triturated with pressure, the particles of powder that adhere to the sides of the mortar and pestle being detached by means of a spatula.

The difficulty with beginners is, that in their haste to obtain a mass, they usually add too much excipient, causing the mass to become soft and pasty. To remedy this, some absorbent powder is generally added, frequently with the result of increasing the size of the pill to that of a bolus. Particular precaution should be observed not to add an excess of water to pill-masses containing soap.

For the preparation of a pill-mass a deep wedgwood or porcelain mortar, of a form similar to that shown in Fig. 349, is preferably selected. Because of their lightness, and the firm grasp

afforded, pestles having a wooden handle are preferred. Fig. 351 illustrates a form specially adapted for this purpose.

After the mass has been formed, it should be given a cylindrical shape with the hands, then placed on a pill tile,* (Fig. 350), and by means of the roller (Fig. 352), which is a piece of hard wood with a smooth surface provided with a handle, or by means of a broad-bladed spatula (Fig. 353), it is rolled out into a long cylinder of the necessary length; then by means of a spatula it is divided into the desired number of parts.

Many operators prefer to roll and divide the mass on the pill machine (Fig. 354). This consists of two pieces of hard wood;

FIG. 349.

Pill Mortar

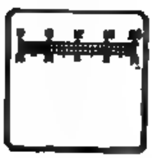
FIG. 351.

Pill Pestle.†

FIG. 352.

Pill Roller (sectional view).

FIG. 350.



Pill Tile.

FIG. 353.

Pill Spatula.

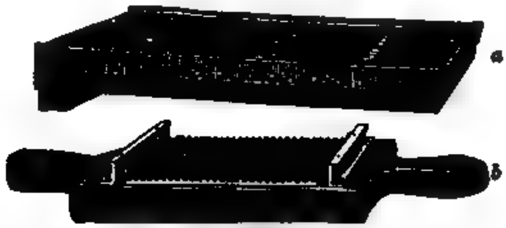
the lower board (*a*) is encased with metal strips to prevent warping, and to protect the raised edges from wear; on the upper end is a hemispherically-grooved brass plate. Corresponding to this is a similar plate on the upper board (*b*), at either end of which are fastened brass guides, so that the cutting edges of the grooved brass plates may accurately correspond in position. This upper board is provided with handles for operating.

* These consist of slabs composed of queensware, porcelain or glass, on one side of which a graduated scale is marked; queensware is objectionable, because of the frequent cracking of the enamel on the surface, which permits the various substances to penetrate, rendering it after a time unfit for dispensing purposes. Glass is open to the objection that in use the surface becomes rough and scratched. Porcelain answers the best.

† Made by Messrs. Whitall, Tatum & Co., New York.

The pill-cylinder, as soon as formed, is laid across the grooves of the lower board; then the upper board, by means of the guides, is brought upon the surface of the mass with a slight downward pressure, and with a backward and forward movement the pill-cylinder is divided into the desired number of pills.

Fig. 354.



Pill Machine.

To facilitate the formation of the cylinders, in the manufacture of large quantities of pills, the pill (or plaster) press of Liebau (Fig. 355) may be employed. The pill-mass is placed in the cylindrical hopper (*b*), which is provided with a double hot water jacket (supplied from *a*), for the purpose of retaining the mass in

Fig. 355.

Liebau's Pill or Plaster Press.

soft condition; then by means of a plunger, operated by a screw, the mass is forced through the apertures in the steel block below, forming cylinders of uniform size.

To prevent the mass from sticking to the pill tile or roller, it is usually dusted with rice flour; lycopodium is also used for

this purpose, but offers the slight disadvantage of color, and causes the mass to slip about when rolled.

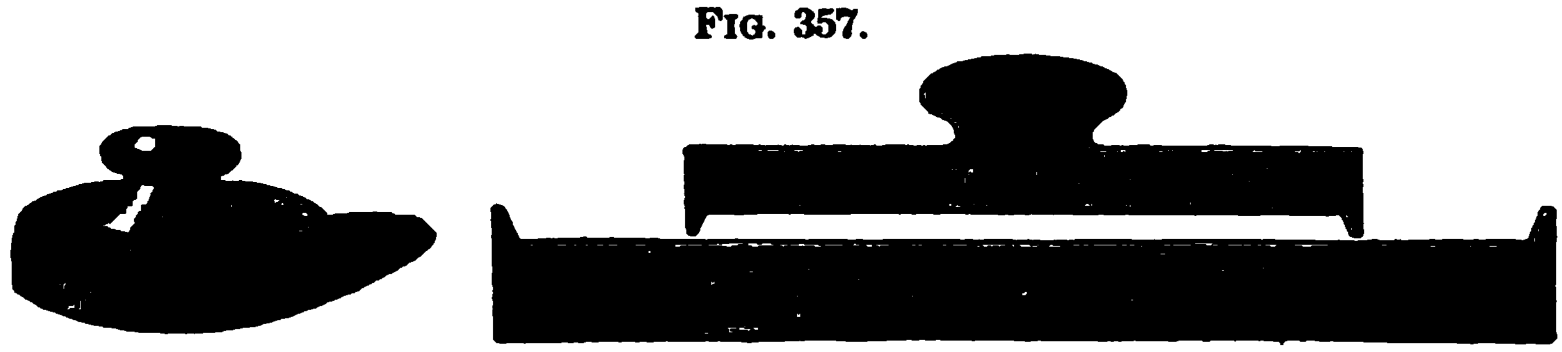
FIG. 356.

Pill Finisher.

After the cylinder has been cut into the necessary number of parts, these are next rounded and finished by rotating them about with slight pressure, on a level, smooth surface, under the pill finisher (Figs. 356–7). This is made of hard wood, and either of a fixed depth of surface or adjustable.

When the mass is of such a nature that it crumbles readily, it

FIG. 357.



Pill Finisher.

is not only permissible, but preferable, to round the pills by rolling them with the fingers.

EXCIPIENTS (*Fluid*).

Such excipients as are incompatible with the pill-mass are to be avoided, for instance, confection of rose with iron compounds; also those excipients which render pills too hard or too soft, likewise those which tend to increase their size unduly.

Water.—This is employed in all cases where the mass possesses sufficient inherent adhesiveness capable of being developed with water, as, for instance, pills of aloes, asafœtida, opium, compound cathartic pills, etc. Pills made with water are, however, liable to become exceedingly hard on standing; hence, when they are to be made in large quantities, it is advisable to add a small amount of glycerin.

Syrup.—This differs from water in being slightly adhesive.

Mucilage or Syrup of Acacia.—While either forms a very adhesive excipient, they should be avoided, since they render the pills very hard.

Glycerin.—This, alone, is a poor excipient, since it is entirely devoid of adhesive properties. It is, however, excellent when used in combination with other excipients (glycerite of tragacanth, etc.), as it will maintain the pills in a soft condition. Owing to its hygroscopic nature, it should be used very cautiously, otherwise the pills soon lose their shape.

Glucose or Honey.—These form excellent excipients, being adhesive and tending to retain the mass in soft condition.

*Glycerite of Tragacanth.**—This forms one of the best general excipients for all sorts of masses. It is adhesive, and does not render the pills hygroscopic.

Castor Oil.—This is employed as an excipient in pills of camphor, also in the official Plummer's Pill.

General Excipient.—A combination of some of the above excipients, possessing their several virtues, forms perhaps the best for general use.

Upham's Formula:

Powd. Acacia,	1 drachm.
Powd. Tragacanth,	2 "
Glucose (white),	5 "
Glycerin,	3 ounces.

Mix the powders in a suitable vessel, and incorporate the glycerin and glucose until a perfectly smooth paste is obtained; then apply sufficient heat until the mass thickens.

Remington's Formula:

Glucose (white),	4 oz. av.
Glycerin,	1 oz. av.
Powd. Acacia,	90 grains.
Benzoic Acid,	1 grain.

In the glycerin contained in a capsule, heated on a water-bath, dissolve the benzoic acid (or better, replace the benzoic acid by 5 drops of Tr. Benzoin); then add the acacia and glucose, and stir well until they are dissolved.

EXCIPIENTS (*Solid*).

Acacia (powdered).—Powdered acacia, by itself, is of but little value, but, when combined with powdered althæa (Hager), it binds well, making a mass of good consistence.

Tragacanth (powdered).—This imparts solidity and elasticity to a mass, particularly if the latter tends to crumble. If too much is added, the mass becomes so elastic that it is almost impossible to render the pills round by rolling.

Soap (powdered).—This is adapted to the formation of pill-masses containing resins, gum-resins, and vegetable powders. In the Pharmacopœia, it is employed in making pills of aloes, aloes and asafœtida, asafœtida, opium and rhubarb. Water should be added very cautiously to these mixtures, otherwise they become too soft. Soap should not be used in masses which contain metallic salts, acid salts, etc.

* *Glycerite of Tragacanth*, N. F.—Tragacanth, pulverized, 2 troy ounces; glycerin, 12½ fluidounces; water, 3 fluidounces. Triturate the tragacanth with the glycerin, add the water (hot) gradually, and continue triturating until a homogeneous paste results.

Althæa (powdered).—This, with a little water, is quite adhesive. When employed as an absorbent it should not be employed in large quantities, since it renders the mass very bulky and elastic.

Powdered Extract of Liquorice.—This forms, with water, an excellent binding material for all sorts of combinations. It should be employed only in masses of dark color.

Pilular Extracts.—Such solid extracts, of pilular consistency, as those of Gentian, Taraxacum or Triticum, form a very useful excipient for a great variety of combinations. It should be borne in mind that they should only be employed in masses which are themselves of a dark color.

Confection of Rose.—This is useful for combining small amounts of active drugs, but is objectionable because of its bulk. The Pharmacopœia directs its use in Pills of Aloes and Myrrh.

Petrolatum.—This, in conjunction with kaolin as diluent, forms the best excipient for pills containing readily oxidizable substances, such as silver nitrate, potassium permanganate, etc.

Suet (Mutton-tallow, benzoinated).—This, with one-third of its weight of white wax, forms the base of all pills which are to be coated with keratin.

If the physician directs some particular excipient, this should be employed, if possible; but, if it be not practicable, the dispenser should follow his own judgment. The selection of excipients should be left to the dispenser, as his practical knowledge enables him better to determine this.

MASSING* OF VARIOUS MIXTURES.

INORGANIC SALTS.

Crystalline salts which are soluble in water, should be finely pulverized and made into a mass with glycerite of tragacanth and a little inert powder, and the pills, when completed, should be varnished with tolu. For making the mass, Canada balsam has been recommended; also, a mixture of the salt (2 parts), powdered soap (1.5 parts), cacao butter (1 part), and petrolatum sufficient; also, a mixture of pulverized liquorice root and glucose; also, after dissolving the salt in the smallest quantity of water, to add enough powdered acacia to form a mucilage, then to add sufficient kaolin to form a mass of proper consistence, which is then to be rolled into pills and varnished.

Such compounds as iodide or bromide of iron, are mixed with powdered marshmallow or liquorice root and powdered acacia, and massed with glycerite of tragacanth.

*By "massing" is meant the conversion of powders or other substances, by means of an excipient, into a plastic condition, suitable for moulding into pills.

Exsiccated iron sulphate is usually directed to be combined with vegetable extracts; here a little glycerite of tragacanth should be added in order to prevent the pills from drying out and cracking.

Reduced iron may be mixed with a little liquorice and massed with glycerite of tragacanth. When combined with vegetable extracts containing acids (such as citric, tartaric, malic, etc.), the pills soon swell and fall to pieces, owing to the evolution of hydrogen arising from the action of the acids on the iron.

Sensitive salts, such as silver nitrate, potassium permanganate, or gold chloride, require an inorganic basis, because the use of any organic substance, even though it be merely a dusting powder, will cause the reduction of these salts when coming in contact with them. For this purpose an inorganic substance, such as kaolin or infusorial earth, is employed as diluent, the mixture is made into a mass with petrolatum, and the finished pills rolled in powdered French chalk. Another base, consisting of a mixture of anhydrous sodium sulphate 1 part, kaolin 2 parts, and water 1 part, has also been recommended.

ORGANIC SALTS.

Alkaloids or potent remedies, which are given in very small doses, should be well triturated with a little sugar of milk and powdered marshmallow or liquorice root, then made into a mass with glucose or glycerite of tragacanth. This procedure answers also, for such inorganic potent remedies as arsenous acid, corrosive sublimate, etc.

Quinine Sulphate is best massed quickly and rolled out after moistening with a little dilute sulphuric acid. Some employ strong sulphuric acid; but this must be operated rapidly, otherwise the mass loses its plasticity. Another method (Kurssteiner's) is to mix intimately 5 parts of quinine sulphate, and one part each of citric acid, powdered tragacanth, and sugar of milk, then to mass with syrup.

Non-adhesive Bodies, such as acetanilid, naphthol, camphor, etc., should be beaten up with one-third of their weight of powdered acacia and massed with glycerite of tragacanth or glucose; or 1 part of powdered tragacanth should be mixed with 5 parts of the substance, and the mixture massed with a drop or so of water.

Benzoic and Gallic Acids make a fair mass with glycerin or Canada balsam.

Croton Chloral or *the Valerianates*, and *very deliquescent salts*, should be mixed with a little inert powder, and made into a mass with glycerite of tragacanth.

Creosote or Carbolic Acid.—It has been recommended to use pulverized animal charcoal as absorbent and to mass with turpentine or Canada balsam. For each minim of either of the above, a mixture of powdered soap (1 part), and powdered liquorice root (5 parts) has also been recommended. Infusorial earth may also be employed as the absorbent. Another method consists in preparing a 50 per cent. jelly, made by melting together gelatin 11 parts, water 24 parts, sugar 5 parts, to which is added creosote 40 parts. This is to be mixed in a slightly warmed mortar with a small quantity of a vegetable powder, and massed. The German Unofficial Formulary directs Creosote 10 parts, Glycerin 2 parts, Ext. Liquorice powd. 10 parts, powd. Liquorice Root 18 parts. The main difficulty experienced with these pills is that most absorbents fail to retain the oily material, but allow it to penetrate to the surface where it is absorbed by the dusting powder or the pill-box.

Volatile Oils and Balsams.—Some absorbent powder should be used in connection with a little soap. What has been said of Creosote applies also to the volatile oils. Hager recommends the addition of one-third to an equal weight of yellow wax * (melted); but this should never be done except as a last resort.

Resins and Gum-Resins.—These should be finely pulverized, and mixed with a little soap, then made into a mass with a few drops of alcohol. When pulverized they may be made into a mass with a little potassium carbonate. Lupulin triturated with ether gives a good mass.

Vegetable Powders.—These require adhesive excipients, such as glycerite of tragacanth, or glucose. Where admissible, certain extracts, for instance those of taraxacum, or gentian, may also be used.

Solid Extracts.—These, when hard or in dry powder, should be made up with water, or syrup, a trace of glycerin being added to prevent undue hardening of the pills.

When pills are dispensed, they should be strewn with some absorbent inert powder, usually lycopodium, or starch, or in those cases in which an organic powder is not admissible, with powdered French chalk. It is not customary to use more of the dusting powder than necessary to cover the bottom of the box.

COATING PILLS.

Pills are coated for the purpose of masking their taste or odor, and for the purpose of adding to their permanency.

*It is not advisable to make a practice of employing wax in making pills, as they are likely to pass the body in an unaltered state, or to remain a long time in the intestines. Wax contains very little that is soluble in the gastric juice or intestinal fluids, and, besides, its melting point (above 63° C.) is too high, as the temperature of the body is only 37 ° C.

Silvering and Gilding.—The coating of pills with silver or gold leaf has become somewhat antiquated. Indeed, it is quite rare, at the present time, that the apothecary is required to perform this.

Pills which contain sulphur, or sulphur compounds, should be first varnished with tolu, so as to prevent blackening of the leaf.

Fig. 358.

Pill Silverer.

The pills which should be free from dusting powder and quite hard, are placed in the hollow cylindrical silvering cup (Fig. 358), then moistened with mucilage of acacia (1 drop for a dozen pills), and rotated so as to distribute this evenly over their surfaces. Then the necessary number of gold or silver leaves are added (one for about 6 pills) and the box is shaken with a rotary motion until all the leaf has been taken up by the pills. The pills should not be made too moist, otherwise a larger number of leaves will be necessary and the finish will be dull.

Varnishing Pills.—Pills containing easily oxidizable substances, such as Phosphorus, Phosphides, Ferrous Iodide or Bromide, deliquescent salts, etc., are usually coated with a varnish. The pills are placed in a flat-bottomed capsule, then sufficient of the ethereal varnish is poured over them to wet them, the dish is covered and then rotated so as to distribute the varnish equally over their surface. They are then transferred to a pill tile, or any glazed surface, and allowed to dry. As a varnish, the Pharmacopœia recommends a solution of balsam of Tolu, 10 parts, in 15 parts of ether.

Hager recommends mastic, 5 parts, and balsam of Tolu, 15 parts, to be dissolved in a mixture of 25 parts of alcohol and 8 parts of ether.

Collodion has also been recommended for this purpose. In this case the coating should be made as light as possible.

Sugar Coating.—Sugar coating can only be carried on successfully on the large scale. This is accomplished in very much the same manner as that employed by the confectioners in coating almonds; a large quantity of pills are rotated in a carefully heated copper kettle with powdered sugar, moistened from time to time with syrup. The smooth coating results from the attrition produced. The polish is imparted by rapidly rotating the finished pills with some pieces of wax, or paraffin.

For coating small quantities of pills, the following formula of C. Faust yields fair results:—

Moisten the pills with a mixture of 1 part of glycerin and 2 parts of absolute alcohol, and throw them into a box containing a liberal supply of a fine powder composed of 4 parts of sugar, 2

parts of tragacanth and 1 part of starch, and roll them around well. Sift them free of the powder, moisten, and again roll them in the powder. To give a glaze to the pills, moisten them with a mixture of 1 part of glycerin and 2 parts of ether, and roll in a powder consisting of equal parts of talc and calcium carbonate.

In making the pills on a large scale the final polish is given by rotating them, after being coated, in a cylindrical vessel with some pieces of hard paraffin.

PEARL COATING.—This consists in covering the pills with a thin layer of powdered French chalk. The pills contained in a cylindrical vessel are moistened with sufficient syrup of acacia to dampen their surface after rotating them; then an excess of very fine French chalk is added and the pills rotated until a smooth, polished surface results. It would be well to add a little powdered saccharin, so as to impart a more pleasant taste to the coating material.

GELATIN COATING.—Gelatin-coated pills owe their popularity to the elegant appearance and ready solubility of this coating. For coating pills on the large scale, the invention of J. B. Russell, of Detroit, is largely employed. This consists in holding the pills securely upon the ends of small tubes by means of suction. The machine consists of a box to which are attached numerous small tubes; the vacuum caused by the air being exhausted from this produces suction, which attracts and holds the pills in position. The latter are then dipped into the gelatin solution, whereby one-half of their surface becomes coated, then they are quickly dried and reversed and again dipped.

Gelatin coating may be readily and quickly imparted on the small scale by using the following gelatin solution:—

French Gelatin (so-called Gold Brand),	4	parts.
Acacia (select pieces),	1	part.
Boric Acid,	0.25	part.
Water,	40	parts.

The gelatin and acacia are macerated in the water for twelve hours, and then dissolved by heating on a water-bath with the boric acid. The vessel should be kept covered during the heating, so as to avoid loss of water by evaporation and the formation of a scum on the surface. This solution, when cold, solidifies to a jelly. It may be kept in this condition and a portion melted when wanted.

The first requisite is that the pill be dry and free from dusting-powder. The simplest form of coater may be made by inserting needles, eye-end down, in a large cork, at a sufficient angle so as not to interfere with one another. The pills are impaled on these, then dipped into the gelatin solution, withdrawn, and then held a moment to allow the superfluous gelatin to collect in the form of a drop, which is removed by touching the surface of the gelatin solution. The cork is then rotated about, so as to permit the gelatin to set evenly over the surface of the pills.

A very convenient machine for gelatin-coating for the use of the pharmacist, is that devised by Mr. Maynard, of Chicago (Fig. 359). The pills are first rolled into the conical indentations of a plate provided for this purpose. A needle-holder is provided, which consists of a circular plate in which are set a number of needles; on either edge of this plate are placed guiding pins, by means of which the operator is enabled to accurately center the pills with the needle points. By means of the handle the needle-holder is pressed downward, until the pills are securely impaled on the needle points. These are then dipped into the solution, as directed above, and rotated; then, after the gelatin film has become cold and sufficiently hard, the pills are removed by a mechanical device, and set aside on little trays to dry. The gelatin solution should be kept constantly covered when not dipping.

FIG. 359.

Gelatin Pill Coater (Maynard).

The coater devised by Prof. Patch (Fig. 360) consists of wooden strips containing 16 needles for impaling the pills. These strips are provided with adjustable handles, so that as soon as the pills have been dipped they may be rotated by hand sufficiently until they have set; then the strips holding the pills are secured on the wheel, which is made to rotate alternately in both directions, for the purpose of securing uniformity of the coating and facilitating the drying. The pills are removed from the needles by means of a comb attached to the box.

FIG. 360.

Gelatin-Coating Machine (Patch).

Keratin or Salol Coating.—In those instances where it is desired to restrict the action of the medicinal agent (such as naphtalin,

koussin, tannic acid, etc.), to the intestinal tract, it is necessary that the pill be coated with some agent which is not acted on by the *acid* gastric juices, so that it may pass undissolved through the stomach into the duodenum, where the *alkaline* secretions cause a solution of the coating and subsequent disintegration of the pill.

For this purpose we have two agents, namely Keratin * and Salol.†

Keratin Coating.—For coating with keratin, oily excipients should be employed in making the pills; one excipient recommended for this purpose consists of a mixture of 3 parts of mutton suet and 1 part of white wax; should other excipients be necessary the pills should be first coated with a thin layer of cacao-butter. The coating solution is made by dissolving 7 parts of keratin in 100 parts of concentrated acetic acid, or 1 part of keratin in a mixture of 10 parts each of ammonia water and water. The pills are placed in a large porcelain capsule, 4 or 5 drops of the keratin solution added, and then rolled about every five or ten minutes for half an hour. Then another addition of a few drops of the solution is made and the pills rotated as before. The procedure may be repeated once or twice more. Another method consists in impaling the pills on needles and applying the solution of keratin with a camel's hair brush. Two applications generally suffice; the first coat should be allowed to dry before applying the second.

Salol Coating.—The pills should be impaled on needles (as in coating with gelatin), then dipped into the melted salol contained in a small, deep capsule. The coating hardens almost as soon as the pills are removed from the bath. Such pills have the appearance of being sugar-coated. The pin-holes left after removing the pills from the needles should be closed by applying a little melted salol with a brush. This coating may be applied to gelatin capsules as well. A coating of 0.2 to 0.3 Gm. of salol suffices to prevent the pill from being crushed by the pressure of the tongue against the palate. The pills must not be bitten, and not be taken with hot food or fluids.

It has been recommended to dip the pills into a saturated (hot) alcoholic solution of salol containing a small amount of shellac.

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* **The Preparation of Keratin.**—Dieterich's modified formula for the preparation of keratin is as follows: Digest 20 Gm. of finely cut goose quills in water for ten hours, and afterward macerate in a mixture of 100 Gm. of ether and 100 Gm. of alcohol for eight days; filter off the liquid, dry the quill, and put it in a large flask containing 200 Gm. of glacial acetic acid; stopper the flask with a perforated cork, and insert a glass tube in the perforation to serve as a condenser. Boil gently in a sand-bath for 20 to 40 hours, and, when the quill is nearly all dissolved, filter through glass-wool and evaporate the filtrate in a porcelain capsule to a syrup; spread this on clean glass plates and dry. Finally, scrape off the keratin in scales.

† Salol is the salicylic ether of phenol, its formula being $C_6H_5C_7H_5O_3$. It is a crystalline compound which melts at 42° C. In the alkaline secretions of the small intestine it is broken up into phenol and salicylic acid.

TABLETTÆ.

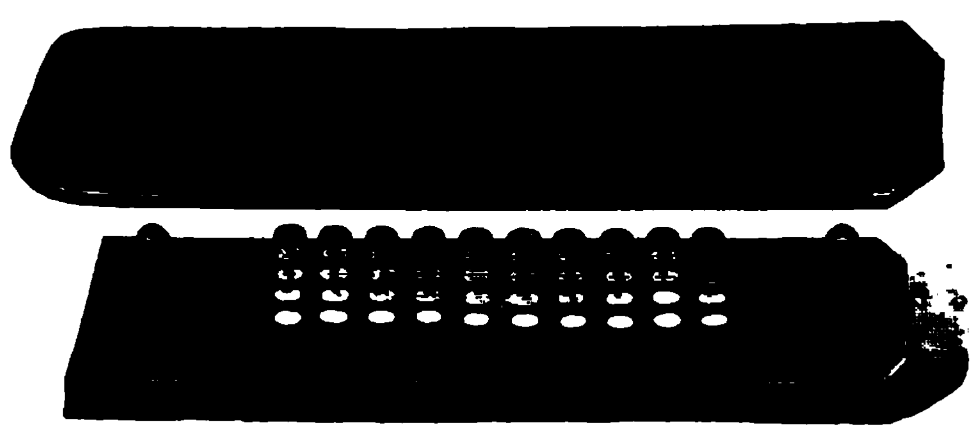
TABLET TRITURATES.

Tablet Triturates consist of the medicine, which, if a dry solid, has been triturated with sugar of milk until a thorough and complete division and distribution of it has been made. In the case of pasty or fluid bodies, these are mixed in a wet state with sugar of milk, the whole dried, and then finely subdivided by trituration. The powder in either case is then formed into a pasty mass with varying proportions of alcohol and water, or other suitable menstruum, and afterwards moulded into tablets of uniform size and weight.

The formula for each separate combination is arrived at in the following way:—

The mould is filled with finely-powdered sugar of milk, which has been wetted to a pasty mass with diluted alcohol. The tablets are then pressed from the mould, thoroughly dried and weighed. This weight is generally sixty-five (65) grains for fifty (50) tablets for the rubber moulds now usually supplied, making a tablet

FIG. 361.



Rubber Tablet Triturate Mould.*

weighing slightly less than one and one-third ($1\frac{1}{3}$) grains when filled with plain milk sugar. The weight of the plain sugar of milk tablet is slightly increased with the increased solvent action of the menstruum, as more of the sugar enters solution, making the tablet more compact. The next step is to ascertain how much milk sugar must be omitted from the previously ascertained amount in order to make room for the medicinal constituents. For this purpose one hundred and thirty (130) grains of milk sugar are weighed off, which is equivalent to one hundred (100) finished tablets of plain sugar of milk. From these 130 grains a bulk is taken, equivalent, as nearly as possible, to that of the substance to be incorporated, and its weight noted. The active ingredient,

* This consists of two parts, the lower, heavier portion bearing the punch-pins, which number fifty for the regular tablet triturates, and one hundred for the hypodermic size. There are two extra, larger and higher pins at either end, which gauge the mould-plate so that the openings come in line with the punch-pins. The upper portion is the mould proper, consisting of a rubber plate with regularly arranged perforations, corresponding in division, size and location of the punch-pins. The mould-plate bears a number which is identical with that upon the plate bearing the pins, and when the tablets are to be pushed through, the two parts must be so adjusted that the ends bearing the numbers come together, and the face of the mould-plate bearing the number must be turned upward.

if a dry solid, is now mixed with the remaining portion of sugar of milk by thorough trituration. In the case of solid extracts, tinctures and other fluids, these are mixed with the remaining portion of sugar of milk, if necessary, by the aid of water or some other menstruum which dissolves them perfectly, then the mass is dried and powdered.

After the mixture has been made, dried and thoroughly triturated, it is wetted with a suitable menstruum, and moulded, care being taken to scrape the mortar as clean as possible in order not to waste any of the material. The tablets are then carefully dried. If there be any mass in excess of that required for the one hundred tablets, it shows that not enough milk súgar has been taken from the original 130 grains. The weight of this excess is generally equal to that of an equal bulk of milk sugar. Hence it will only be necessary, at the next trial, to remove as much more milk sugar as the bulk of this excess amounts to.

If there should be less than one hundred tablets, the weight of the number deficient is ascertained by determining the average weight of the finished tablets, and deducting the calculated weight of the missing tablets from the weight of the bulk of the sugar of milk originally separated. At the next trial the amount of milk sugar removed from the original 130 grains should be as much less, as the weight of the missing tablets amounted to.

In each case the formula finally found, by actual experiment, to yield a correct result, should be noted in a special book, for the purpose of future reference.

It is important that all the ingredients, and the mixture of powders ready for moulding, should be in the finest possible state of subdivision. If they are coarse, the tablets will not show a smooth, finished appearance.

In tablets composed nearly all of sugar of milk, if the latter be in coarse powder, it necessitates the addition of more water to the alcohol than is required when the milk sugar is in very fine powder. The menstruum selected should possess a slight solvent action upon one or more of the ingredients, but the latter should not be too freely soluble, since the mass is then moulded with difficulty, and the tablets prepared therefrom will be uneven, sometimes being cracked on the surface and very hard. It should possess sufficient solvent action to make a firm, yet not too hard a tablet, one that will hold firmly together when shaken in a vial, and which should readily disintegrate upon the addition of water. It is, however, impossible to prepare all the various combinations in such form that they readily dissolve or diffuse upon the addition of water, the rapidity of disintegration depending upon the proportion and soluble character of the constituents.

The menstrua generally used are alcohol, absolute alcohol, alcohol and water, and chloroform. For tablets composed nearly entirely of sugar of milk, a menstruum composed of three volumes of alcohol and one volume of water is preferable. For

bodies insoluble in alcohol the proportion of water is raised in proportion to the increase of active ingredient. The menstruum must, therefore, be so adjusted that it will dissolve enough of either the milk sugar, or of the active ingredient, to make a sufficiently firm tablet. As examples may be quoted: reduced iron, binoxide of manganese, oxalate of cerium, bismuth subnitrate and subcarbonate, and the higher strength calomel tablets. For codeine, podophyllin, leptandrin, aloin, and bodies very soluble in alcohol, it is better to use water exclusively for moulding.

For such tablets in which a chemical reaction takes place between the various constituents, with the formation of a new product which is desired, a menstruum must be selected which does not exert a soluble action upon *all* of the active constituents. For example, we combine sodium bicarbonate with saccharin, in order to increase the solubility, thereby intensifying the sweetness of the latter; as a menstruum for moistening, we employ absolute alcohol, as it exerts a solvent action on the saccharin only, yet binding the constituents to a firm tablet.

In the case of fluid extracts and tinctures, thorough trituration with the milk sugar is generally sufficient to produce a homogeneous mass for drying. Solid extracts produce more difficulties. If water is to be used as diluent, not more than the absolutely required amount should be employed, since any excess will cause the mass to form lumps or large cakes, and render the subsequent drying difficult. After the mass is dried, it must be reduced to a fine powder, previous to being moulded. To form a paste, the best liquid in this case is a mixture of alcohol three volumes and chloroform one volume. Water alone usually renders the mass too sticky, and alcohol alone is not adapted to aqueous or hydro-alcoholic extracts, since the extracts abstract the water from the alcohol, and thus produce an unmanageable adhesive mass.

In preparing the powder for moulding, it should be wetted to a pasty consistence, the mould be placed upon a smooth surface, a pill tile answering admirably, and the wetted powder pressed into the spaces with a horn or ivory spatula which is drawn over the mould. Sometimes the mass adheres to the spatula and is drawn from the holes. This is remedied by dipping the spatula in the menstruum used for wetting the mixture before drawing it over the surface. The mould is then reversed by sliding it toward and off the edge of the tile without raising it, the spatula is drawn over the other side of the mould and the latter then again drawn toward and off the edge. The tablets are now pressed out by the punch pin plate and allowed to dry a few minutes upon the punch pins, then shaken off by striking the pin-plate forcibly upon the counter covered with a sheet of paper to receive the tablets.

If the tablets are to be finished as speedily as possible, it is advisable to blow heated air over the surface of the side of the mould which comes in contact with the punch pins. This is best accomplished by holding the mould some distance from a gas

flame and blowing the upper extremity of the flame towards the mould, the force of the breath carrying considerable heated air with its help to dry the surface quickly. Care should be exercised, if the mould is of rubber, that not too great a heat be directed toward the mould, otherwise it will warp. Moreover, if alcohol has been used for moistening, care must be taken to prevent ignition of the vapor. The rubbing of some dry powder (dry milk sugar or lycopodium) over the side of the mould to come next to the punch pins, helps to absorb the excess of moisture and prevents the tablets from sticking to the punch pins.

The tablets should never be left in the moulds over ten minutes, because if they are allowed to dry in the mould, they cannot be pressed from it without crumbling.

The drying process is best completed by placing them upon a sieve which exposes their entire surface, and allows more rapid evaporation of the menstruum. This is particularly necessary when the tablet is colored by the active ingredient, in solution in the menstruum. If such a tablet were dried while lying on a solid surface, the coloring matter would, by the law of capillarity, be deposited near the upper surface, and hence this side would be darker in color than the lower, the evaporation having been entirely from the upper end, while upon the sieve it will be from the entire surface, the color being equally distributed near the entire surface of the tablet, the interior always being lighter in color.

In preparing tablets upon a large scale they are allowed to dry upon the punch pins in a draught of slightly warmed dehydrated air. When nearly dry, they are scraped from the punch pins and the drying completed in a hot-air chamber.

For hypodermic tablets, sugar of milk is well adapted, and the rules to follow for their preparation are exactly similar to those for the Tablet Triturate. The rubber hypodermic mould, usually sold, makes tablets which weigh about three-quarters of a grain. The menstruum, used for most of the combinations, is three volumes of alcohol and one volume of water. In some of the higher strength morphine tablets it is necessary to use diluted alcohol.

When solid extracts are to be combined into tablets, the mass should be moistened with a menstruum, composed of a mixture of alcohol three volumes and chloroform one volume.

COMPRESSED TABLETS.

Compressed tablets consist of some medicinal substance, or a mixture of substances, compressed to the form of a disc. The substance or mixture which is to be compressed must be in a granular form, either in its original granular condition, or prepared in a granular state by aid of a medium, such as cane sugar, or gum arabic, with the aid of water.

In the preparation of compressed tablets it is important that the ingredients be brought by trituration to a very fine state of subdivision before being granulated, unless the substance is originally granular, or in a firm, hard crystalline form, from which a granular preparation may be obtained by grinding in a mill or mortar.

If the material is compressed in the form of fine powder, it is difficult to be formed into uniform and nicely finished tablets. Not only does the powder not feed well into the mould, but, when pressure is applied, the air confined in the interstices of the powder has no chance of escaping, and is apt to produce tablets of irregular surfaces, edges, and weight, with a tendency to stick to the powders and die.

To overcome these difficulties the substance is granulated by adding one-tenth of its weight of cane sugar and one-twentieth of its weight of acacia, thoroughly mixing and moistening with water until it is of such consistence that it can readily be forced through a No. 12 sieve without sticking to it, or clogging it. It is then dried. The finished granulation should always be perfectly dry, as a damp granulation occasions a great deal of trouble by sticking to the dies, and punches. The granulation is now forced through a No. 20 sieve, and the particles which do not readily pass through the meshes are forced through by the aid of a flat pestle. In adding the water to make the granulation, it should be thoroughly and evenly incorporated so that all the particles contain as nearly as possible an equal amount of moisture. The water is best added in small portions at a time.

Some substances can be bought already granulated, and these, therefore, require no further preparation, and can be compressed in their original granular condition; for instance, ammonium chloride, potassium bromide, sodium bromide, potassium chlorate, potassium iodide. Some few crystalline salts, if in the form of hard crystals, without having lost any of their water of crystallization, can be ground in a mill to granular powder, or may be crushed to a granular form in a mortar; for instance, sodium phosphate and sodium sulphate.

Cane sugar is the best material to use for granulating, as tablets prepared with it disintegrate or dissolve more quickly than those prepared with acacia. For beginners, it is better to use the cane sugar and acacia together as directed above, as this mixture is best adapted for granulating almost anything obtainable in a pulverulent condition.

Before the granulation is compressed, it is necessary to add a lubricant. This is a hydrocarbon oil entirely free from odor, the proportion added depending upon the character of the material. Ten to twelve drops is usually sufficient for one pound of the granulation. It is best added by means of a spray, and further mixed by stirring the mixture upon paper, or by dropping the oil into a mortar, adding about one-fortieth of the bulk of the material, mixing well by rubbing gently so that the granulation may be as little as possible reduced to powder, then adding the remainder of the granulation, and stirring gently.

The hydrocarbon oil possesses the property of lubricating the different particles, allowing them to glide by each other freely, easily falling into the mould space, feeding the same amount each time, and thus making the finished tablets equal in weight. While the granulation is undergoing compression, the greater proportion of the oil is forced to the surface and edges of the tablet, preventing the sticking of particles of the material to the die and faces of the punches.

Finely powdered French chalk is used in connection with the hydrocarbon oil, its properties being likewise that of a lubricant. The proportion used should be just as small as possible, not more than one-fortieth of the weight of the material. It should be added after the oil.

Boracic acid is also used as a lubricant in such cases where the tablet is required to form a clear solution. It does not act so well as the French chalk.

The more perfect and even the granulation has been prepared, the smaller the quantity of lubricant which it is necessary to use.

In the preparation of compressed tablets from solid extracts, fluid extracts and tinctures, the two latter are to be concentrated to a syrupy consistence. A solid extract is best rubbed to a syrupy consistence by the aid of water. In both cases there should be no small particles of undissolved extract, as these would give the finished tablet a mottled or spotted appearance.

If the quantity of extract to be contained in a tablet is small, say one-fourth of a grain of extract contained in a tablet weighing two grains, the excess of water may be absorbed by finely powdered starch, of which as much as 25 per cent. of the weight of the tablet may be added, if necessary, the principle being to leave the mixture of starch and extract sufficiently wet so that it may exert the required solvent action upon the remaining ingredients to form a proper consistence for granulation. If too much starch has been added, the extra quantity of water required is easily added to the mixture of starch, extract, and other material. When a tablet is to contain two or more grains of extract, the addition of the required amount of starch, so that the product will pass through a No. 12 sieve, would make it too large. Therefore, when the extract is in large proportion, it is a good plan to add to it half its weight of starch after it has been

softened, then to dry the mass upon a steam-bath, and finally to crush it in a mortar, or to grind it in a mill to a No. 20 granulation.

When a caked mass is to be reduced, by rubbing in a mortar, to a No. 20 granule, the material should be transferred to the sieve at short intervals, in order to separate that portion which has been reduced to the proper fineness; otherwise, by continued rubbing, the greater portion of the material would be reduced to a fine powder.

Extracts may also be incorporated in the form of a dry, impalpable powder, if the proportion be small, and in such cases it is also a good plan to add some powdered starch to the material and extract; next, sufficient water is added, and well incorporated, the mixture passed through a No. 12 sieve, then dried, and, lastly, forced through a No. 20 sieve. It is not necessary to use any adhesive material, such as acacia or cane sugar, for tablets containing extracts, unless the proportion of extract be very small. Spongy bodies like charcoal must be in impalpable powder, and not less than 25 per cent. of cane sugar should be added for granulation. If the charcoal cannot be obtained in a finely subdivided state, it is a good plan to add the proportion of sugar as above, to wet the mixture to such a state that it forms small cakes, and to dry perfectly. The cakes are then reduced to very fine powder, moistened with sufficient water to make the mass pass through a No. 12 sieve, the granulation dried, and then reduced to granules, passing through a No. 60 to 80 sieve.

The powdered pepsin of the market is of a spongy nature, like charcoal, and is best prepared for compressing by adding one-tenth of its weight of cane sugar, then spraying diluted alcohol over the mixture, mixing thoroughly until all particles have been moistened, but are still in about No. 80 powder, then drying and compressing.

Spongy substances should be fed to the machine in a very finely granular form. The large size granules offer too much resistance to the punches, and the tablet crumbles very easily. Spongy bodies, as a rule, require no lubricant.

Scale pepsin and most of the other scale preparations can be compressed by reducing them to No. 30 or 40 granules, and lubricating them.

Salts containing water of crystallization, organic or inorganic, which cannot be compressed without being first granulated, as, for example, lead acetate, zinc sulphate, alum and quinine sulphate, are best treated in the following manner:—

The salt is reduced to a fine powder, mixed with one-twentieth of its weight of powdered gum arabic, moistened sufficiently with water to pass it through a No. 12 sieve, dried, again reduced to fine powder, mixed with one-tenth of its weight of cane sugar, moistened with just enough water to make it pass through a No. 12 sieve, then dried, first without, and lastly by aid of heat. The

mixture is then forced through a No. 20 sieve, lubricated and compressed.

Bodies which are hygroscopic or deliquescent are best granulated with gum arabic exclusively, taking one-tenth of the weight of the substance and water for moistening.

Combinations of rhubarb and soda are best granulated by adding to them one-tenth of their weight of cane sugar, and granulating with a mixture of one volume of glucose, 1 volume of water and three volumes of alcohol, well mixed, this mixture preventing the action of the alkali upon the rhubarb.

Glucose is an excellent medium for making tablets hard and tough, so that they will not readily disintegrate, as, for example, lozenges which are intended for slow solution in the mouth. To improve the lozenge, the greater portion of the material should be cane sugar, with 10 per cent. of gum arabic, and the glucose should be diluted with 25 per cent. of water before being added.

In tablets to form effervescing solutions or to form new compounds when added to water, the constituents should be granulated *separately*, and mixed in a perfectly dry granular condition just before being compressed.

A very important quality which compressed tablets should possess is that of rapid disintegration and solution. This is brought about by adding finely powdered starch, to the amount of from one-twentieth to one-tenth of the weight of material, to the granulated substance ready to be compressed. It is most important for certain insoluble bodies, such as phenacetin, acetanilid, sulphonal, etc., that they disintegrate rapidly. These are best granulated with one-tenth of their weight of cane sugar, water being used for moistening. As stated before, the addition of acacia retards rapid disintegration and solution; hence it should not be used where cane sugar acts as a sufficiently adhesive agent.

Fig. 362 illustrates the simplest form of a compressed tablet machine; this consists of a cast steel cylinder, into the base of which fits a short post with a concave surface. A steel plunger, having a corresponding concave depression on its lower extremity, is used for compression. The granule is introduced into the cylinder, and after inserting the plunger, a quick, sharp blow is struck by means of a wooden mallet, whereby the powder is compressed; then, after the cylinder is removed from the base, the plunger is tapped, which forces the tablet out into a proper receptacle. An improvement on this is the tablet machine illustrated in Fig. 363. Its construction is simple, being operated by means of a lever. It is capable of turning out tablets quite rapidly. For the preparation of large quantities of tablets, the larger machines of the market afford all that is desirable.

The pressure used for compressing the tablets should be just as light as possible, for the firmer the pressure the slower the disintegration of insoluble bodies, firm pressure not affecting very

soluble substances, since their solution takes place from the surface. The pressure should be regulated so that the tablets may readily be broken in half by the fingers, but should not break to pieces when dropped upon the floor. With a light pressure the material has a greater tendency to stick to the face of the punches.

The dies and punches should be of very hard temper and should be kept in good condition. They should be polished from time to time by the aid of finely powdered emery, preferably on a lathe. If this is not at hand, a round smoothened end of a piece of wood answers very well, and is used by dipping the end in oil, then in the emery, and rubbing over the surface of the punches. For polishing the dies, a rounded piece of wood, a little

FIG. 362.

Compressed Tablet Mould.

FIG. 363.

Compressed Tablet Mould. (W., T. & Co.)

smaller than the bore of the die, dipped in the oil and emery, is well adapted.

If the surface of the dies and punches is not kept smooth and polished, the material works into the uneven surface and adheres to it, making a tablet with rough surface and scraped edges, necessitating the frequent cleaning of the faces of the punches.

If the dies be of soft temper, such bodies as exert considerable friction, as acetanilid, phenacetin, and antipyrin, will wear down the die quickly in that portion where the tablet is compressed, and by the constant wear the die is widened at this spot, especially at the point of the upper and lower surface of the tablet where there is the most wear, hence the tablet is slightly wider than the bore of the remaining portion of die. In being forced upwards

to be expelled from the die, the tablet is forced into a narrower space than that into which it had been compressed, which tends to bend it and loosen the flat or convex upper or lower surface, which may readily be split off by the thumb nail, but which will fall off spontaneously after the tablet has been shaken about some little time. This is termed "capping."

The best remedy for the "capping" is a hard-tempered die; but this is not always at hand. Dampening the granulation very slightly with water will prevent it; but this increases the adhesive qualities, and the material is more liable to stick to the punches. However, if these are smooth and well polished, little trouble will be experienced from the sticking qualities.

Reducing the pressure is another remedy; but, if the punches are not in good condition, the material will stick to them.

Changing the weight of the tablet is still another remedy, the tablet to be compressed in a portion of the die that is not worn.

EXTRACTA—(*Extracts*).

EXTRACTS are solid or semi-solid preparations obtained by the evaporation of solutions of the medicinal principles of drugs.

According to the solvent employed in exhausting the drug they are designated as alcoholic, hydroalcoholic, aqueous, ethereal, acetic, or ammoniated extracts.

The strength of these preparations bears no definite relationship to the drug, for the amount of solid extract * obtained depends on the nature of the drug, the solvent employed, and the mode of preparation. The more *aqueous* the menstrua, the greater is the yield of extract, the more *alcoholic* the menstrua, the smaller the yield.

It must be remembered that the activity of most drugs resides, as a rule, in certain definite principles, which generally constitute the smallest portion of the bulk of an extract; the other constituents of the drug, embracing gums, starch, inert extractive, coloring matters, etc., constitute the larger *inert* portion soluble in water. Hence, the solvent selected for extraction must be such as to take up all the active, with as little of the inert matter as possible. If an unscrupulous manufacturer were to employ water or a feebly alcoholic menstruum for extracting a drug whose active principles are soluble in alcohol only, he would obtain a large yield of inert extractive matter, while his neighbor who employs alcohol only, would obtain a very small yield of a very active preparation. If both products were sold in the market at equal rates, the former would be a fraud upon the public. Extracts also vary in consistence. Some are as liquid as honey, others have the consistence of a pill mass, and still others are hard and dry, hence there is not likely to be any uniformity of strength, with such variations as these. Therefore, unless there is some guarantee of intrinsic value based on its alkaloidal strength or physiological activity, no reliance can be placed on the strength of one extract as compared with another.

Solid extracts are prepared either—

(*a*) *From the dried and powdered drug, by extraction with a solvent, or*—

(*b*) *From the fresh, moist drug, by expression alone.*

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* Prepared with *official* menstrua (U. S. Pharmacopœia, 1880), the yield in extract is, according to J. Lammer, Jr., "Proceed. Amer. Phar. Association," 1887, p. 35:—

	Per cent.		*Per cent.*
Extractum Aconiti,	12.76	Extractum Hyoscyami (alc.),	16.64
" Aloes,	91.54	" Iridis,	8.90
" Arnicæ Radicis,	19.53	" Juglandis,	16.82
" Belladonnæ Alcoholicum,	32.23	" Krameriæ	8.40
" Cannabis Indicæ,	16.56	" Leptandræ,	15.97
" Cinchonæ,	26 40	" Mezerei,	7.10
" Colchici Radicis,	23.20	" Nucis Vomicæ,	6.17
" Colocynthidis,	15.13	" Opii,	49.60
" Conii,	10.73	" Physostigmatis,	6.20
" Digitalis,	25.50	" Podophylli,	8.31
" Euonymi,	18.31	" Quassiæ,	2.24
" Gentianæ,	44.60	" Rhei,	25.66
" Glycyrrhizæ Purum,	25.32	" Stramonii,	14.02
" Hæmatoxyli,	5.30	" Taraxaci,	11.30

(*a*) When solid extracts are prepared from the dried drugs by extraction, the following rules should be observed:—

1st. Only the best obtainable drug should be employed. Poor drugs cannot be expected to yield active preparations; it is, therefore, advisable to exercise the greatest care in their selection.

2d. That, whatever process of extraction is employed, it should be carried to as complete an exhaustion of the drug as possible. Extraction is effected by the process of maceration (15–20° C. for 24 to 48 hours), or digestion (35–40° C. for 12 hours) with expression; or by percolation.

3d. That the menstruum selected will deprive the drug of its active principles with as little inert matter as possible. The various menstrua directed by the Pharmacopœia have been selected with this view; hence, an alteration of the menstruum with a view to economy is a reprehensible practice.

4th. The concentration of the liquid extract of the drug should take place as rapidly, and at as low a temperature as possible. Under no circumstances should it be heated over a direct flame.

The greatest care is necessary in conducting the evaporation of extracts from such drugs as conium, blackhaw, valerian, etc., for in these the virtues reside mainly in volatile products; hence the slightest degree of overheating destroys their therapeutic value. The temperature of a water-bath or carefully regulated steam-bath is sufficient, while the fluid is being kept constantly in motion; a stirring arrangement, specially adapted for the use of the apothecary is shown in Fig. 97, page 72. The evaporation should be conducted as rapidly as possible to avoid prolonged heating of the fluid. For this purpose the vacuum apparatus is employed (Fig. 106, page 77). The various methods of conducting evaporation are explained in detail under Vaporization.

(*b*) Certain plant drugs, when recently gathered and subjected to expression, yield their juices, impregnated with all their active principles; these juices, when evaporated, constitute a class of extracts generally known as Succi Spissati, or inspissated juices. Among the drugs adapted to this treatment are taraxacum, belladonna, hyoscyamus, and colchicum. The plants should be worked up immediately after being collected, being cut into pieces and bruised until reduced to a pulp. In case the plant is not very succulent, a little water should be added to assist in diluting and extracting the juice. The pulp is then enclosed in a canvas bag and subjected to expression. The juice thus obtained from fresh plants, or leaves, is of a more or less green color, due to the presence of chlorophyll.

When heated to about 70° C., the albumen of the juice coagulates, forming a precipitate which encloses the suspended impurities. These are readily removed by filtration. The subsequent concentration is carried out as already explained.

PHYSICAL CHARACTERS AND PRESERVATION OF EXTRACTS.

The Pharmacopœia recognizes two degrees of consistence—the soft, or pilular, and the hard extract. The pilular consistence should be such that the extract readily admits being rolled into pills, which retain their shape. Twenty-five of the official extracts should be of this consistence. The pilular extracts of the market vary considerably as regards their consistence, many being exceedingly soft, while others are quite hard.

The hard extracts, of which seven are official, admit of being reduced to powder. The dispensing conveniences which a powdered extract offers, have led to the general introduction of all the various extracts in powder form.

The indiscriminate substitution of these powdered extracts in place of the official pilular product is to be condemned, for the heat necessary to reduce the extracts to the proper degree of dryness is, in many instances, sufficient to destroy most or all the virtues of the drug contained in them. Again, many extracts cannot be brought, by themselves, to a sufficiently dry condition; hence, they must be mixed with various diluents, such as sugar of milk, starch, the powdered drug itself, etc.; then spread out in thin layers, and exposed in a warm (30–40° C.), dry place; then reduced to a powder, and preserved in well-closed vials. It will be seen from this, that another cause of variation of strength of these powdered extracts is the admixture of inert matter, to which there is no definite limit.

Extracts should be preserved in closely covered jars, it being best to place the jar of extract in a canister having a close-fitting lid. Some extracts readily dry out and become very hard. In such cases it is well to moisten the surface with a little glycerin.

Other extracts, owing to the presence of deliquescent salts, are quite hygroscopic, and absorb moisture readily. Still others become inert on standing for a long time, due to an alteration of their principles by the action of the air.

Many extracts (as those of stramonium, hyoscyamus, belladonna, etc.), contain numerous crystals of inorganic salts (potassium nitrate or chloride, etc.). The presence of these is manifested by the grittiness of the extract when rubbed on a slab under a spatula. Such extracts should always be rubbed with a few drops of water before being combined into ointments or suppositories.

The official extracts are 33 in number, 25 being of pilular consistency and 7 dry. According to the menstrua employed for exhaustion, they may be classified thus:—

Title. I. ALCOHOLIC EXTRACTS.	*Dose—Grammes.*
Extractum Aconiti,	0.006–0.015
" Cannabis Indicæ,	0.008–0.06
" Cimicifugæ,	0.2 –0.3
" Iridis,	0.06 –2.0
" Jalapæ,	0.1 –0.3
" Physostigmatis,	0.006–0.03

II. HYDRO-ALCOHOLIC EXTRACTS.

Extractum Arnicæ Radicis,	0.1 -0.3
" Belladonnæ Foliorum Alcoholicum,	0.008-0.05
" Cinchonæ,	1. -2.0
" Colocynthidis,	0.03 -0.1
" Conii (with acetic acid),	0.01 -0.1
" Digitalis,	0.008-0.05
" Ergotæ (with acetic acid),	0.2 -1.0
" Euonymi,	0.06 -0.2
" Hyoscyami,	0.06 -0.2
" Juglandis,	0.3 -0.2
" Leptandræ,	0.06 -0.3
" Nucis Vomicæ (with acetic acid) (assayed),	0.01 -0.06
" Podophylli,	0.06 -0.3
" Rhei,	0.3 -1.0
" Stramonii Seminis,	0.01 -0.2
" Uvæ Ursi,	0.3 -1.0

III. AQUEOUS EXTRACTS.

Extractum Aloes,	0.2 -0.6
" Colchici Radicis (with acetic acid),	0.06 -0.1
" Gentianæ,	0.3 -0.6
" Glycyrrhizæ,	.. ..
" Glycyrrhizæ Purum (with ammonia water),	.. ..
" Hæmatoxyli,	0.3 -2.0
" Krameriæ,	0.3 -2.0
" Opii (assayed),	0.01 -0.06
" Quassiæ,	0.06 -2.0
" Taraxaci,	0.5 -2.0

IV. COMPOUND EXTRACTS.

Extractum Colocynthidis Compositum,	0.3 -1.5

EXPLANATORY.

EXTRACTUM NUCIS VOMICÆ.—The menstruum selected for the extraction of nux vomica must be of such a character that it will readily take up the alkaloidal principles and yet as little of the fatty oil as possible.* The forty-eight hours' maceration with the acidified menstruum of alcohol, 3 parts, and water, 1 part, is necessary for the softening of the tissues preparatory to extraction. The presence of the acetic acid greatly assists the solution of the alkaloids. As the extract is directed to be reduced to a powder, it is necessary to first remove the fixed oil present. This is accomplished by washing the extract obtained from the concentration of the percolates with ether.

Since some of the alkaloids are associated with the fat which has been removed, it is necessary to remove these by washing the fat with acetic acid and hot water.

After completion, a portion of the extract is assayed for alkaloids. In another portion, the amount of water is determined. From these results the total percentage of alkaloids in the dry extract is calculated, enough sugar of milk being added to bring the amount of total alkaloids in the dry extract up to 15 per cent.

Example.—A sample of extract of nux vomica, prepared by the process of the U. S. Pharmacopœia, assayed 16 per cent. of alka-

* Dilute acetic acid fulfills these conditions better than the official menstruum.

loids, and contained 22 per cent. of moisture. How much sugar of milk should be added to bring it to the pharmacopœial requirement of 15 per cent. of alkaloids when dry?

I. Since the moisture or water which is present has, eventually, all to be evaporated off, it need not be taken into account further than to deduct it from 100, whereby the percentage of *dry* extract is obtained. The further calculation will have to deal only with this.

The extract contains $100 - 22 = 78$ per cent. of dry substance. According to the assay, the 100 parts of moist, or 78 parts of dry extract contain 16 parts of alkaloids. The next step will be to ascertain how much of these 78 parts of dry extract will contain 15 parts of alkaloids:—

(*Equation 1.*) $16 : 15 :: 78 : x;\quad x = 73.125.$

Since 73.125 parts of the dry extract contain 15 parts of alkaloids, it will only be necessary to dilute these 73.125 parts with sugar of milk to 100 parts in order to convert the 15 *parts* of alkaloids into *percentage*:—

(*Equation 2.*) $100 - 73.125 = 26.875.$

That is, for every 73.125 of dry extract, 26.875 parts of sugar of milk will have to be added. But the original extract contains 78 parts of dry substance. Hence, the amount of sugar of milk required for this (which is equal to 100 parts of the moist extract) will be found by the proposition:—

(*Equation 3.*) $73.125 : 78 = 26.875 : x;\quad x = 28.667$ parts.

II. The same result may be arrived at in another manner.

The extract contains $100 - 22 = 78$ per cent. of dry substance, and this contains 16 *parts* of alkaloids. Calculated to *percentage*, this would become:—

(*Equation 4.*) $78 : 100 = 16 : x;\quad x = 20.513.$

That is, 100 parts of a dry extract of the same strength as the 78 parts just mentioned, would contain 20.513 parts of the alkaloids. Now, since every 15 parts of alkaloids are augmented in this product to 20.513 parts, it will only be necessary to dilute the original extract with sugar of milk in the proportion of 15 to 20.513:—

(*Equation 5.*) $15 : 20.513 = 78$ of dry extract ($= 100$ moist) $: x.$
$x = 106.667.$

That is, to every 78 parts of dry extract, or to every 100 parts of moist extract, there will have to be added:—

(*Equation 6.*) $106.667 - 78 = 28.667$ parts of sugar of milk.

III. Based upon either of the foregoing methods, which are really identical and differ only in form, a general formula may be derived. Let the several values be expressed by letters, as follows:—

m = percentage of moisture in the moist extract.
a = " " alkaloids " " "
d = " " dry substance " "
x = amount of sugar of milk required to be added to every 100 parts of the moist extract, to make it contain 15 per cent. of alkaloids, when dry.

Then we have, using equation (3), but substituting in it general terms derived from equations (1) and (2), and remembering that $d = 100 - m$:—

(*Equation 7.*) $\frac{15\,d}{a} : d = (100 - \frac{15\,d}{a}) : x.$

$$x = 6.667\,a - d.$$

Or, we may derive this value from equations (6) and (5), in a similar manner:—

(*Equation 8.*) $\frac{100\,a}{15} - d = x\,;\ \ x = 6.667\,a - d.$

The rule, therefore, expressed in words, would be: To find the amount of sugar of milk required to be added to 100 parts of moist extract of nux vomica of known percentage of alkaloids and moisture, in order to make it contain 15 per cent. of alkaloids when dry, *multiply the percentage of alkaloids found with 6.667, and deduct therefrom the percentage of dry extract.*

Assay of Extract of Nux Vomica:—

Extract of Nux Vomica, dried at 100° C. (212° F.), *two grammes*, (2 Gm.).
Alcohol,
Ammonia Water,
Water,
Chloroform,
Decinormal Sulphuric Acid (V. S.),
Centinormal Potassium Hydrate V. S., each, *a sufficient quantity.*

"Put 2 Gm. of the dried Extract of Nux Vomica into a glass separator, add to it 20 Cc. of a previously prepared mixture of 2 volumes of alcohol, 1 volume of ammonia water (specific gravity 0.960), and 1 volume of water, and shake the well-stoppered separator until the extract is dissolved. Then add 20 Cc. of chloroform and agitate during five minutes. Allow the chloroform to separate, remove it as far as possible, pour into the separator a few Cc. of chloroform, and, without shaking, draw this off through the stopcock to wash the outlet-tube. Repeat the extraction with two further portions of chloroform of 15 Cc. each, and wash the outlet-tube each time as just directed. Collect all the chloroformic solutions in a wide beaker, expose the latter to a gentle heat, on a water-bath, until the chloroform and ammonia are completely dissipated, add to the residue 10 Cc. of decinormal sulphuric acid measured with great care from a burette, stir gently, and then add 20 Cc. of hot water. When solution has taken place, add 2 Cc. of brazil wood T. S., and then carefully run in centinormal potassium hydrate V. S., until a permanent pinkish color is produced by the action of a slight excess of alkali upon the brazil wood indicator. Divide the number of Cc. of centinormal potassium V. S. used by 10, subtract the number found from 10 (the 10 Cc. of decinormal acid used), multiply the remainder by 0.0364 and that product by 50 (or, multiplied at once by 1.82), which will give the percentage of *total alkaloids* in the Extract of Nux Vomica, it being assumed that strychnine and brucine are present in equal proportion, and the above factor being found by taking

the mean of their respective molecular weights rounded off to whole numbers [(334 + 394) ÷ 2 = 364.] (U. S. Pharmacopœia.)"

As to the glass separator, the bulbed or pear-shaped form (50 Cc. capacity) as shown in Fig. 296, should be used. The extract readily dissolves in the mixture of alcohol and water, the ammonia water serving to liberate the alkaloids from their combination with igasuric acid; the chloroform added dissolves the liberated alkaloids. After the chloroform is added, the mixture should be shaken by a rotary motion in order to avoid emulsification. When the chloroform once becomes emulsionized, it is a difficult matter to bring about a separation of the fluids. After the usual number of subsequent extractions, the chloroformic solutions, upon evaporation, yield an alkaloidal residue consisting of a mixture of strychnine and brucine, assumed to be in equal proportions.

Alkaloids, being strong bases, are capable of neutralizing acids in definite proportions. Hence, the usual method of estimating alkalies by means of a standard solution of an acid can be applied to certain alkaloids with a great degree of accuracy. The reaction is as follows:—

$$\underset{\substack{\text{Sulphuric Acid.}\\ 2\times 97.82}}{2H_2SO_4} + \underset{\substack{\text{Strychnine.}\\ 2\times 333.31}}{2C_{21}H_{22}N_2O_2} + \underset{\substack{\text{Brucine.}\\ 2\times 393.17}}{2C_{23}H_{26}N_2O_4} = \underset{\text{Strychnine Sulphate.}}{(C_{21}H_{22}N_2O_2)_2H_2SO_4} + \underset{\text{Brucine Sulphate.}}{(C_{23}H_{26}N_2O_4)_2H_2SO_4}$$

	Sulphuric Acid.		Strychnine.		Brucine.
One molecule of	97.82	=	333.31	+	393.17 = 726.48 total.
1000 Cc. $\frac{N}{10}$ containing	48.91	=	363.24 ($\frac{1}{2}$ of 726.48) alkaloids.		
1 Cc. " "	0.04891	=	0.0364 alkaloids.		

Hence each cubic centimeter of decinormal sulphuric acid is equivalent to 0.364 gramme of total alkaloids.* Since the usual indicators are not sufficiently sensitive in the presence of the alkaloids, the Pharmacopœia directs the use of Brazil-wood test solution, which strikes a yellow color with acids and a pinkish color with alkalies. When operating with this indicator, it is always advisable to place alongside of the actual test-sample, on a piece of white paper, two beakers, each containing a like volume of water and indicator, to one of which about 1 Cc. of the normal acid has been added, and in the other the equivalent amount of alkaline volumetric solution; with these beakers as a means of comparison, the change of color in the solution for assay can be more conveniently fixed.

Example.—The chloroformic residue obtained from 2 grammes of extract, which has been dissolved in 10 Cc. of decinormal sulphuric acid, required 28 Cc. of centinormal potassium hydrate V. S. for neutralization. What percentage of total alkaloids does the extract contain?

We have dissolved the alkaloids in an excess (10 Cc.) of the decinormal acid. In order to ascertain how much of the acid has not been neutralized by the alkaloids, we titrate back with

---

* Assuming them to be present in equal proportions.

centinormal potassium hydrate, and subtract the equivalent amount of the latter from the former, thus: 10 Cc. of $\frac{N}{10}$ H_2SO_4, minus 2.8 Cc. of $\frac{N}{10}$ KOH (which is the same as 28 Cc. of $\frac{N}{100}$KOH), leaves 7.2 Cc. of decinormal acid which has been neutralized by the alkaloids. Then, if 1 cubic centimeter of $\frac{N}{10}$ $H_2SO_4 = 0.0364$ Gm. of alkaloid, 7.2 Cc. of the acid $= 7.2 \times 0.0364 = 0.26208$ Gm. of alkaloid. Therefore, there are 0.3057 Gm. of total alkaloids (strychnine and brucine) present. The percentage may be found as usual $(0.26208 \div 2 \times 100 = 13.10 +$ per cent.), or as directed by the Pharmacopœia by multiplying by 50 $(50 \times 0.3057) = 13.10 +$ per cent.

ABSTRACTA (*Abstracts*).

ABSTRACTS are powdered extracts, the strength of which bear a definite and uniform relation to the drug. This class of preparations were introduced into the Pharmacopœia of 1880, but because of their unpopularity* they were dropped from the present Pharmacopœia of 1890. The strength of the abstracts represents twice that of the drug or of the fluid extract from which they are prepared.

The general formula directed by the Pharmacopœia of 1880 is as follows:—

"Drug, in No. 60 powder, *two hundred parts* [or four ounces av.]; Sugar of Milk, recently dried and in fine powder, Alcohol, each, *a sufficient quantity*, to make *one hundred parts* [or two ounces av.]. Moisten the drug with *eighty parts* [or one and three-quarter fluidounces] of Alcohol, and pack firmly in a cylindrical glass percolator; then add enough Alcohol to saturate the powder and leave a stratum above it. When the liquid begins to drop from the percolator, close the lower orifice, and, having closely covered the percolator, macerate for forty-eight hours. Then allow the percolation to proceed, gradually adding Alcohol, until the drug is exhausted. Reserve the first *one hundred and seventy parts* [or three and one-half fluidounces] of the percolate, evaporate the remainder to *thirty parts* [or half a fluidounce] at a temperature not exceeding 50° C. (122° F.) and mix with the reserved portion. Place the mixture in an evaporating dish, and, having added *fifty parts* [or one ounce av.] of Sugar of Milk, cover it with a piece of thin muslin gauze, and set aside in a warm place, where the temperature will not rise above 50° C. (122° F.), until the mixture is dry. Lastly, having added enough Sugar of Milk to make the mixture weigh *one hundred parts* [or two ounces av.], reduce it to a fine, uniform powder. Preserve the powder in a well-stopped bottle."

The abstracts recognized by the U. S. Pharmacopœia of 1880 were Abstractum Aconiti, Belladonnæ, Conii, Digitalis, Hyoscyami, Ignatiæ, Jalapæ, Nucis vomicæ, Podophylli, Senegæ, and Valerianæ.

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* It is unfortunate that this class of preparations of definite and uniform strength should not be able to supplant a class characterized by so little uniformity and so great a variation as the solid extracts. Their principal disadvantage being their bulk as compared to the solid extracts.

RESINÆ—(*Resins*).

These are solid preparations usually obtained by exhausting certain drugs with alcohol and precipitating the resinous principles by addition of water.

The procedure is applied to those drugs whose activity resides in resinous principles.

The Pharmacopœia recognizes four resins, three of which are prepared in the following manner: The drug is exhausted with alcohol; after concentration of this alcoholic extract to a syrupy consistence it is poured slowly, with constant stirring, and in a thin stream, into a large excess of cold water, the precipitate is allowed to subside, washed by decantation, strained off, and dried with a gentle heat. Resin of podophyllum is precipitated with acidulated* water, in order to facilitate its separation, the acid imparting at the same time a brighter yellow color to the resin. The water used in precipitating this resin should be *cold*, and the resin dried by exposure to air in a cool place. Resin of copaiba, being one of the two constituents of balsam of copaiba, is more readily separated by distilling off the volatile oil.

RESINÆ, U. S. P.

Title.	*Preparation.*	*Dose.*
Resina Copaibæ, ...	Product remaining after distillation.	0.3 to 1.5 Gm.
" Jalapæ, ...	Precipitation.	0.1 to 0.3 Gm.
" Podophylli, . . .	"	0.008 to 0.05 Gm.
" Scammonii, . . .	"	0.2 to 0.5 Gm.

RESINOIDS—(*Eclectic*).

These are a class of resinous powders or medicinal substances obtained by precipitation of the alcoholic tinctures of certain plants or plant-parts, either by means of water alone or aided by heat, or by acids or other agents.

If the drug contains an oleoresin, it is necessary, in order to bring the precipitate to a powder form, to mix it with a sufficient quantity of the powdered drug.

Such resinoids as hydrastin and sanguinarin are precipitated in water acidulated with an acid or rendered slightly alkaline with ammonia water.

These preparations, the names of which generally end in *-in*, should not be confounded with the similarly sounding alkaloids or other active plant principles.

They vary greatly in their activity, owing to various impurities and to the fact that many do not represent all the virtues of the plants from which they are obtained.

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* Water containing alum is also employed, but yields a product contaminated with alumina.

The following list includes most of these preparations, with their average doses,* such as are given by eclectic authorities:—

	Obtained from	*Average dose in grains.*
Aconitin,	Aconite Root,	1/24–1/12
Aletrin,	Star Grass,	1/4–2
Alnuin,	Tag Alder Bark,	2–10
Ampelopsin,	American Ivy,	2–4
Apocynin,	Bitter Root,	1/4–1
Atropin,	Belladonna,	1/24–1/12
Asclepin,	Pleurisy Root,	2–4
Baptisin,	Wild Indigo Root,	1–3
Barosmin,	Buchu,	2–3
Betin,	Beets,	2–4
Bryonin,	White Bryony,	1/4–2
Caulophyllin,	Blue Cohosh,	1–5
Cerasein,	Choke Cherry,	2–10
Chelonin,	Balmony,	1–2
Chimaphilin,	Pipsissewa,	2–3
Chionanthin,	Fringe Tree,	1–3
Cimicifugin,	*See Macrotin*,	1/4–2
Collinsonin,	Stone Root,	2–4
Colocynthin,	Bitter Apple,	1/4–1
Cornin,	Dogwood,	2–4
Corydalin,	Turkey Pea,	1–3
Cypripedin,	Lady Slipper,	1–3
Digitalin,	Foxglove,	1/4–1/2
Dioscorein,	Wild Yam,	1/4–4
Ergotin,	Ergot,	1/16–1/2
Erythroxylin,	Coca Leaves,	1/4–1
Euonymin,	Wahoo,	1/4–3
Eupatorin (Perf.),	Boneset,	1–3
Eupatorin (Purp.),	Queen of Meadow,	1–4
Euphorbin,	Blooming Spurge,	1/4–3
Eupurpurin,	Queen of Meadow,	1–4
Frazerin,	American Colombo,	1–3
Gelsemin,	Yellow Jessamine,	1/4–1
Geraniin,	Cranesbill,	1–3
Gossypiin,	Cotton Root,	1–5
Hamamelin.	Witch Hazel,	1–3
Helonin,	False Unicorn,	2–4
Hydrastin,	Goldenseal,	1–2
Hydrastin Mur.,	Goldenseal (Berberina)	1–3
Hydrastin Sul.,	" "	1–2
Hydrastin Nit.,	" "	1–2
Hydrastin Phos.,	" "	1–2
Hyoscyamin,	Henbane,	1/4–1
Inulin,	Elecampane,	1–3
Irisin,	Blue Flag,	2–4
Jalapin,	Jalap,	1–3
Juglandin,	Butternut,	2–5
Leontodin,	Dandelion,	2–4
Leptandrin,	Culvers Root,	2–4
Lobelin,	Lobelia,	1/4–3
Lupulin,	Hops,	1–2
Lycopin,	Bugle Weed,	1–4
Macrotin,	Black Cohosh,	1/4–2
Menispermin,	Yellow Parilla,	1–4
Myricin,	Bayberry,	1–3
Phytolaccin,	Poke Root,	1–3
Prunin,	Wild Cherry,	2–3
Populin,	Poplar,	2–4
Podophyllin,	Mandrake,	1/4–3
Podophyllin Neut.,	"	1/4–2
Ptelein,	Wafer Ash,	1–3
Rhein,	Rhubarb,	1–4
Rhusin,	Sumach,	1–2
Rumin,	Yellow Dock,	1–3
Sanguinarin,	Blood Root,	1–3
Scutellarin,	Scullcap,	1–2
Senecin,	Life Root,	1–3
Smilacin,	Sarsaparilla (Hon.),	2–5
Stillingin,	Queen's Root,	1–3
Trilliin,	Beth Root,	2–4
Veratrin,	Am. Hellebore,	1/4–1/2
Viburnin,	Cramp Bark,	1–3
Viburnin Prunif.,	Black Haw,	1–3
Xanthoxylin,	Prickly Ash,	1–2

* These drugs are subject to some variation, according to the manufacturer.

CHAPTER XXXV.

SOLIDS.

II. FOR EXTERNAL USE.

UNGUENTA—(*Ointments*).

OINTMENTS are soft, unctuous preparations, composed of fats, generally medicated, which are applied to the skin by inunction.

An ointment consists of medicinal agents combined with a vehicle, which is generally of the consistence of lard.

VEHICLE.—The U. S. Pharmacopœia directs, in most instances, the use of benzoinated lard or simple ointment. Among other vehicles proposed and in use are petrolatum, wool-fat, diachylon ointment; mixture of yellow wax (3 parts) and olive oil (7 parts), mixtures of such fats as spermaceti, suet or cacao-butter with almond oil; mixture of expressed oil of nutmeg (6 parts), olive oil (2 parts), yellow wax (1 part), etc.

The three most popular vehicles, namely, *benzoinated lard*, *wool-fat*, and *petrolatum*, should not be used indiscriminately.

Petrolatum is not adapted for use as an absorbent vehicle. For this reason it should never be substituted where lard or wool-fat is directed. It answers as a bland neutral protective dressing.

Wool-fat forms the best vehicle for dermal medication; it is more readily absorbed by the skin than lard, does not become rancid, and is miscible with aqueous solutions to the extent of its own weight. When inorganic salts are to be combined with it, they should be first dissolved in a little water, and then added to the wool-fat.

Lard is not as readily absorbed by the skin as wool-fat, but owing to its cheapness, and the readiness with which it may be purified, it forms the most popular vehicle. It is often objectionable because of its tendency to rancidity; but, if properly purified and benzoinated, it can, with care, be kept almost indefinitely.

Ointments, according to the method of preparation, are made either (1) by *fusion*, (2) by *mechanical admixture*, or (3) by *chemical reaction*.

1st. BY FUSION.—In preparing ointments by fusion, those substances which have higher melting points should be fused first, then the balance of the fats added, the whole strained, if necessary, well stirred, and, while it cools, such additional substances incorporated as may be directed. The fats should be melted by the heat of a water-bath, and never directly over the flame.

2d. BY MECHANICAL ADMIXTURE.—A large variety of substances are directed to be incorporated into ointments. The admixture may be accomplished either by trituration in a mortar or by

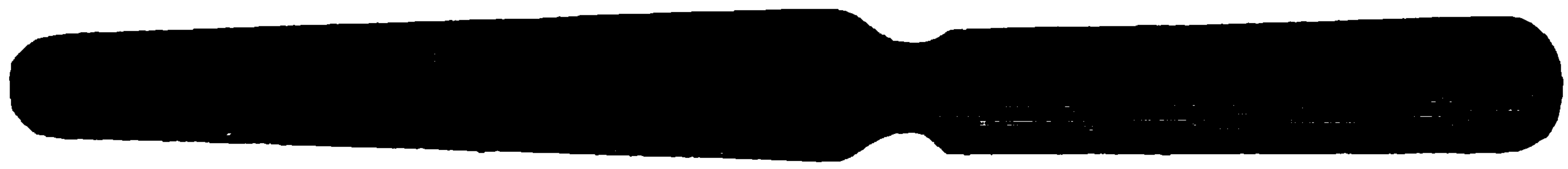
working the materials, on an ointment slab,* with a spatula (Fig. 364). In handling such materials as iodine, corrosive sublimate, salicylic acid, tannic acid, etc., a steel spatula should not be used, but, in place of it, one of horn or hard rubber should be substituted.

When solids are to be incorporated, they should be first reduced to a very fine powder, then intimately mixed with a small portion of the fat, after which the remainder is gradually and thoroughly incorporated, until a perfectly homogeneous mixture is obtained.

Solid extracts are first reduced to a smooth, thick paste by addition of a few drops of a solvent (water, alcohol, etc.), and rubbing in a mortar, or on a pill-tile with the spatula; then they are incorporated with the base, as directed above.

When comparatively large amounts of dry powders are directed to be incorporated into an ointment, in order to prevent lumping, the powder should be triturated in a warm mortar with a portion of the melted fat. When this is reduced to a smooth, uniform paste, and the fat begins to cool, the remainder should be added gradually, and the whole thoroughly mixed.

FIG. 364.



Ointment Spatula.

Soluble salts, such as zinc sulphate, mercuric chloride, silver nitrate, etc., which are prone to crystallize, should be rubbed to a smooth paste with a little olive or almond oil before being incorporated; glycerin should not be used for this purpose. No more oil should be employed than is absolutely necessary.

Very soluble or deliquescent salts, such as potassium iodide or carbonate, zinc chloride, etc., should be rubbed with a few drops of water.

As exception to the above procedure, tartar-emetic should be mixed, in the state of a fine powder, directly with the ointment.

Alkaloids should be first dissolved in a little oleic acid before being mixed with the vehicle.

Aqueous fluids† should be combined slowly by trituration; alcoholic liquids are difficult to combine in ointments. If the active constituents in the alcoholic liquid are not volatile, it may be evaporated at a low temperature to the consistence of an extract, and then incorporated in the ointment.

* A convenient substitute for this is the so-called Diamond Ointment Pad, made by Fox, Fultz & Webster, of New York. This consists of a block-pad made of parchment-paper, which is impervious to fats and liquids of all kinds. Immediately after use, the soiled leaf is torn off, thus saving the labor and time of cleansing.

† Lard will take up mechanically and hold about one-fifth, Petrolatum about one-tenth, and Wool-fat about its own weight of aqueous fluid.

The quantities of fat should be *weighed* (waxed paper being used), and not guessed at. Immediately after the completion of an ointment, the mortar or slab should be cleansed by rubbing it with sawdust, the last traces of fat removed with paper, and the utensil afterward cleaned with soap-suds.

3d. BY CHEMICAL REACTION.—There is only one official example of this, namely, ointment of mercuric nitrate (page 355).

PRESERVATION AND DISPENSING.

Ointments should be kept in well-closed jars, in a cool and dark place. It is well to cover the surface of the ointment with paper impregnated with Tincture of Benzoin.

Never dispense an ointment which has the slightest degree of rancidity.

Fresh ointments should never be placed in a jar containing old ointment, even though there be but traces present.

Ointments should be perfectly smooth and free from solid particles.

Ointments should be dispensed in glass or porcelain jars (gallipots), imparting a smooth finish to the surface of the ointment before dispensing.

Before being refilled, the jars should be thoroughly cleansed. Wooden or lacquered pasteboard boxes should not be used, as the fat quickly penetrates and renders them unsightly.

It is often necessary to mask the odor of certain medicinal agents. For this purpose Cumarin, Heliotropin, or the Oils of Rose, Geranium, Neroli, etc., are employed.

Ointments of a firm consistence may be spread on linen and preserved in rolls, which forms a very convenient method of dispensing them.

The U. S. Pharmacopœia recognizes 23 ointments.

UNGUENTA, U. S. P.

Title.	*Per Cent. of Active Constituent.*	*Base.*
UNGUENTUM, ...	Lard, 80 % ; Yellow Wax, 20 %.	
Acidi Carbolici, ...	Carbolic Acid, 5 %.	Unguentum.
Acidi Tannici, ...	Tannic Acid, 20 %.	Benz. Lard.
Aquæ Rosæ, ...	. . . .	Spermaceti, White Wax, Exp. Oil Almond, Stronger Rose Water, Sodium Borate.
Belladonnæ, ...	Ext. Belladonna Leaves, 10 %.	Benz. Lard.
Chrysarobini, ...	Chrysarobin, 5 %.	Benz. Lard.
Diachylon, ...	. . . .	Lead Plaster, Olive Oil, Oil Lavender fl.
Gallæ, ...	Nutgall, 20 %.	Benz. Lard.
Hydrargyri, ...	Mercury, 50 %.	Lard and Suet.
Hydrargyri Ammoniati, .	Ammoniated Mercury, 10 %.	Benz. Lard.

Title.	Per Cent. of Active Constituent.	Base.
UNGUENTUM—		
Hydrargyri Nitratis, . . .	Mercuric Nitrate, about 12½ %.	Lard Oil.
Hydrargyri Oxidi Flavi, .	Yellow Mercuric Oxide, 10 %.	Unguentum.
Hydrargyri Oxidi Rubri, .	Red Mercuric Oxide, 10 %.	Unguentum.
Iodi, ...	Iodine, 4% (with KI).	Benz. Lard.
Iodoformi, ...	Iodoform, 10%.	Benz. Lard.
Picis Liquidæ, ...	Tar, 50 %.	Yellow Wax and Lard.
Plumbi Carbonatis, . . .	Lead Carbonate, 10 %.	Benz. Lard.
Plumbi Iodidi, ...	Lead Iodide, 10 %.	Benz. Lard.
Potassii Iodidi, ...	Potassium Iodide, 12 %.	Benz. Lard.
Stramonii, ...	Ext. Stramonium Seed, 10 %.	Benz. Lard.
Sulphuris.	Washed Sulphur, 30 %.	Benz. Lard.
Veratrinæ, ...	Veratrine, 4 %.	Benz. Lard.
Zinci Oxidi, ...	Zinc Oxide, 20 %.	Benz. Lard.

EXPLANATORY.

UNGUENTUM HYDRARGYRI.—On triturating or agitating mercury with certain solids or fluids, it will be found that after a time the mercury gradually loses its metallic appearance and assumes a gray color. This mass, on close examination, will be seen to consist of globules of mercury in a very minute state of division.

To accomplish this subdivision, or "extinction," as it is more properly called, a great variety of substances have been recommended, varying according to the use for which the mercurial preparation is intended; that is, internally or externally. The various substances employed act by enclosing each globule of mercury, as rapidly as separated, with a thin coat of material, which prevents it from reuniting with the rest; the presence of a trace of water causes the globules to unite again.

Among the extinguishing agents are chalk, honey, fats, oleic acids, resinous tinctures, confection of rose, wool-fat, mercurial ointment, oleate of mercury, etc.

Oleate of mercury, as recommended by the Pharmacopœia, forms perhaps one of the best and most satisfactory extinguishing agents. The triturating should not be accompanied by pressure, but the motion should be light and rapid; then, as soon as the mercury has disappeared and a dull-gray colored magma is formed, the fused and partly cooled fats should be gradually added with continued trituration, until a portion, when spread out in a thin layer on a piece of white paper, does not reveal globules of mercury under a lens magnifying ten diameters.

On the large scale this subdivision of the mercury is carried on by "succussion" in an apparatus operated by machinery, the mercury being extinguished by means of fused fats or powders.

On long standing, mercurial ointment becomes slightly darker, owing to the oxidation of the mercury.

UNGUENTUM HYDRARGYRI NITRATIS (Citrine Ointment).—By the action of nitrous acid or mercuric nitrate on the "non-drying

oils" (olive, almond, lard, neatsfoot, etc.), the olein of the oil is converted into an isomer called elaidin, which is characterized by its yellow color and butyraceous consistence.

The preparation of citrine ointment depends on the formation of this elaidin, which serves as a vehicle for the mercuric nitrate.

The first step of the process is to heat the oil with a portion of the nitric acid, which suffers reduction to nitrous acid. The latter, in turn, converts the olein into elaidin. Care should be taken not to raise the temperature above that directed (100° C.). The effervescence produced is not of a violent nature, but proceeds quietly and slowly, the liquid mass assuming thereby an orange (not brown) color.

After the addition of the mercuric nitrate (obtained by the action of a reserved portion of the nitric acid on the mercury), the mass should be stirred constantly until cold, by which time it will have assumed a semi-solid consistence and a bright lemon-yellow color. Overheating causes the ointment to assume a brown color. Either a horn, porcelain, or wooden spatula should be employed for stirring, because of the readiness with which mercuric nitrate attacks metals.

CERATA—(*Cerates*).

Cerates (*cera*, wax) are a class of preparations similar to ointments, but of a firmer consistence.

They are made by mixing oil or lard with wax, or some other substance having a higher melting point, imparting to them a consistency between that of an ointment and plaster. When applied to the skin they do not melt like ointments, but retain their soft consistence. The materials selected (oil or lard) should be free from all traces of rancidity.

The wax or materials of higher fusing point should be first melted on a water-bath, then the oil or lard added in portions; when all is liquefied, the fluid should be stirred constantly while cooling, and those portions which congeal on the sides of the vessel re-incorporated until the whole assumes the proper consistence.

Cerates should be kept in a cool place, in clean and well-covered jars. Those made with white wax, owing to its incipient rancidity, are liable to become rancid, while those containing yellow wax keep unaltered.

Cerates are employed chiefly as dressings for inflamed surfaces.

*Steatins.**—These are a class of preparations which have the consistence of cerates, and contain suet combined with wax or lead plaster as vehicle.

The U. S. Pharmacopœia recognizes 6 Cerates.

CERATA, U. S. P.

Title.	*Composition.*
Ceratum, ...	White Wax, 300 Gm. ; Lard, 700 Gm.
Ceratum Camphoræ, ...	Camphor Liniment, 100 Gm. ; White Wax, 300 Gm. ; Lard, 600 Gm.
Ceratum Cantharidis, ... Blistering Cerate,	Cantharides pulv., 320 Gm. ; Yellow Wax, 180 Gm.; Resin, 180 Gm.; Lard, 220 Gm.; Oil of Turpentine, 150 Cc.
Ceratum Cetacei, ... Spermaceti Cerate,	Spermaceti, 100 Gm.; White Wax, 350 Gm.; Olive Oil, 550 Gm.
Ceratum Plumbi Subacetatis, . . Goulard's Cerate,	Solution of Lead Subacetate, 200 Gm.; Camphor Cerate, 800 Gm.
Ceratum Resinæ, ... Basilicon Ointment,	Resin, 350 Gm.; Yellow Wax, 150 Gm.; Lard, 500 Gm. In cold weather, Resin, 350 Gm.; Yellow Wax, 120 Gm.; Lard, 530 Gm.

* Proposed by Mieleke, *Phar. Centralhalle*, 1881, Nos. 20–21.

EMPLASTRA—(*Plasters*).

PLASTERS are compounds of various fusible solids of a melting point higher than that of the human body, being friable when cold, but rendered adhesive by the warmth of the body. According to the vehicle employed, they may be designated as *Plasters proper*, or as *Resinous Plasters*. Emplastrum Plumbi forms the vehicle of the former class, while the latter consists of various combinations of resins.

The Pharmacopœia recognizes two ready-spread plasters, namely, Emplastrum Ichthyocollæ and Emplastrum Capsici.

In the preparation of plasters, care should be taken that no higher degree of heat be employed than that of the water-bath, otherwise decomposition of the volatile medicinal constituents might ensue.

Some plasters are made by simply fusing the various constituents together; others require the admixture of various solids, which are added to the fused mass either in a state of fine powder, or in the condition of a smooth paste obtained by treatment with a proper solvent. While cooling, the mass should be well stirred to insure uniformity in composition.

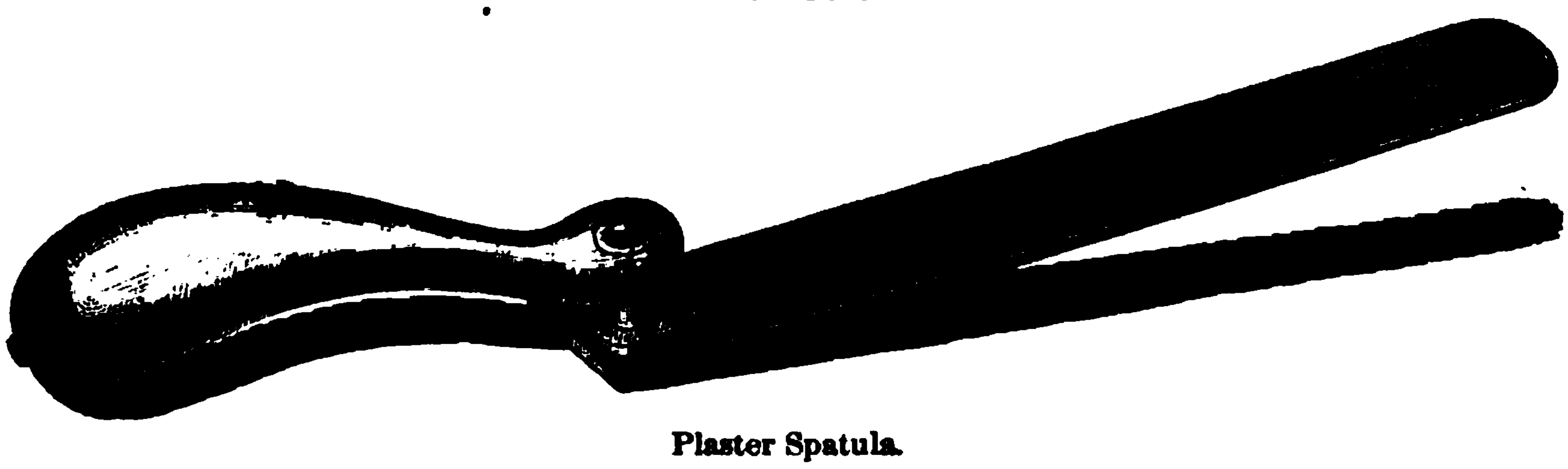
After preparation, the plaster mass is usually moulded* into sticks or rolls, and wrapped in waxed or paraffin paper.

When kept for some time the plaster mass becomes hard and brittle, due to the oxidizing influence of the air; it may be restored to its original plasticity by re-melting it, with the addition of a little oil.

Owing to the introduction of the rubber base, the preparation of plasters has almost entirely fallen into the hands of the manufacturer; it is seldom that the dispenser is required to spread other than cantharides plaster.

SPREADING OF PLASTERS.—Plasters are usually spread on either muslin or leather (sheepskin), which is cut to the necessary size

FIG. 365.



Plaster Spatula.

and shape, from one-quarter to one inch being allowed all around for a margin. The piece of leather or muslin is then stretched

* The Plaster-press, as shown in Fig. 355, page 321, is adapted for this purpose.

evenly on a smooth surface, being held in position by means of thumb-tacks. Over this is laid the form (Fig. 366), made of thin card-board or heavy paper, cut of the desired shape and size, and this is secured firmly by means of thumb-tacks.

FIG. 366.

Forms for Spreading Plasters and Cerates.

Plasters of an ointment-like consistence (like Emp. Cantharidis) may be readily spread in a cold condition by means of a spatula.

The plasters proper, because of their friable nature, are first melted and then spread with a hot spatula.* Sufficient of the

FIG. 367.

Plaster Block.

FIG. 368.

Plaster Iron.

plaster-mass (for the surface required) is selected and cautiously melted in a porcelain capsule over a gas-flame; the melted mass is then allowed to cool until it is of a honey-like consistence and,

* The form shown in Fig. 365 is specially designed for this purpose.

by means of a warm spatula blade, *quickly* and evenly spread over the surface. The mass should not be applied too hot, otherwise it will penetrate the leather or muslin. After the plaster is spread, the surface should appear even and smooth; if it is not, a hot spatula should be quickly passed over it. Care should be taken, while heating the blade, to remove all particles of plaster adhering to it, otherwise the surface of the plaster will become discolored. Before removing the paper, or cardboard frame, the hot edge of the spatula should be passed around the line of contact, so that, when the frame is removed, a smooth, sharp edge may be left.

For spreading larger numbers of plasters, the operation may be facilitated by the employment of the plaster-block (Fig. 367). This consists of a rectangular block of hard wood, the upper surface of which is convex. To one end of the upper surface is attached, by means of a hinge, a sheet-iron frame with an opening of the size desired for the plaster. The muslin or leather of proper size is laid on the convex surface of the block; over this is secured the sheet-iron frame, then the necessary amount of melted and partly-cooled plaster is poured in the center, and by means of a heated (triangular-shaped or round) plaster iron (Fig. 368), it is spread uniformly over the surface, the excess of plaster being forced over on the edges of the frame.

Perforation of Plasters.—This is done to permit the escape of exhalations from the skin, also to enable the plaster to adapt

Fig. 369.

Plaster Perforating Machine.

itself better to the skin, and to adhere more firmly. Perforation of plasters is carried on by the manufacturers of plasters on the large scale, by means of specially constructed machinery. For

the use of the apothecary the perforating machine of Lentz is particularly adapted (Fig. 369). An inexpensive perforating apparatus has been devised by Professor Remington (*Amer. Jour. Phar.*, 1878, p. 171), which consists of a brass cylindrical wheel studded with steel punches, which is driven with some force across the surface of the plaster, resulting in perforating along the line of contact.

The employment of a rubber mass, as a base, has practically superseded all others. Its advantages reside in its flexibility and adhesiveness at ordinary temperatures, and in its not requiring any heat in applying or removing. This base consists essentially of a mixture of rubber with certain resins (burgundy pitch and olibanum), variously medicated. This pliable and adhesive rubber base retains its soft consistence indefinitely, and yields its medicinal constituents readily when applied to the skin.

EXPLANATORY.

EMPLASTRUM PLUMBI (Lead Plaster).—When fats are treated with alkali hydrates or with a number of other metallic oxides, decomposition takes place, the fatty acids combining with the metals forming *soaps*, while the glycerin is set free. Those soaps whose base is either soda or potassa, are known as the "*soluble*," while those whose base constitutes a metallic oxide, are known as "*insoluble*" soaps. To this latter class Lead Plaster belongs. It may be prepared in either of two ways, viz.:—

1st. By the interaction between soluble soaps and lead salts, (page 287).

$$\underset{\text{Sodium Oleate.}}{\begin{matrix}NaC_{18}H_{33}O_2\\NaC_{18}H_{33}O_2\end{matrix}} + \underset{\text{Lead Acetate.}}{Pb\begin{matrix}\diagup C_2H_3O_2\\\diagdown C_2H_3O_2\end{matrix}} = \underset{\text{Lead Oleate.}}{Pb\begin{matrix}\diagup C_{18}H_{33}O_2\\\diagdown C_{18}H_{33}O_2\end{matrix}}$$

2d. By the process of saponification * (U. S. P. process).

$$\underset{\text{Olein (Olive Oil).}}{2C_3H_5(C_{18}H_{33}O_2)_3} + \underset{\text{Litharge.}}{3PbO} + \underset{\text{Water.}}{3H_2O} = \underset{\text{Lead Oleate.}}{3Pb(C_{18}H_{33}O_2)_2} + \underset{\text{Glycerin.}}{2C_3H_5(OH)_3}$$

Any oil which consists of nearly pure olein may be used for this purpose.

The U. S. Pharmacopœia recognizes 13 Plasters.

EMPLASTRA, U. S. P.

PLASTERS CONTAINING EMP. PLUMBI AS BASE.

Emplastrum Ferri, ...	Ferric Hydrate, 90 Gm.; Olive Oil, 50 Gm.; Burgundy Pitch, 140 Gm.; Lead Plaster, 720 Gm.
" Hydrargyri, . .	Mercury, 300 Gm.; Oleate of Mercury, 12 Gm.; Lead Plaster, sufficient quantity, to make 1000 Gm.
" Opii, ...	Ext. Opium, 60 Gm.; Burgundy Pitch, 180 Gm.; Lead Plaster, 760 Gm.; Water, 80 Gm.

* In the restricted sense, as employed here, *saponification* is the separation of fats into their respective acids and glycerin. Here, the fatty acids are liberated by the action of the litharge (in the presence of water), uniting with the lead and separating out as an insoluble soap.

PLASTERS CONTAINING EMP. PLUMBI AS BASE.—*Continued.*

Emplastrum Plumbi, ...	Lead Oxide, 3200 Gm.; Olive Oil, 6000 Gm.; Water, sufficient quantity.
" Resinæ, ...	Resin, 140 Gm.; Lead Plaster, 800 Gm.; Yellow Wax, 60 Gm.
" Saponis, ...	Soap, 100 Gm.; Lead Plaster, 900 Gm.; Water, sufficient quantity.

PLASTERS—RESINOUS.

Emplastrum Ammoniaci cum Hydrargyro, .	Ammoniac, 720 Gm.; Mercury, 180 Gm.; Oleate of Mercury, 8 Gm.; Dilute Acetic Acid, 1000 Cc.; Lead Plaster, sufficient quantity.
" Arnicæ, ...	Ext. Arnica Root, 330 Gm.; Resin Plaster 670 Gm.
" Belladonnæ, . .	Alc. Ext. Belladonna Lvs., 200 Gm.; Resin Plaster, 400 Gm.; Soap Plaster, 400 Gm.
" Picis Burgundicæ,	Burgundy Pitch, 800 Gm.; Olive Oil, 50 Gm.; Yellow Wax, 150 Gm.
" Picis Cantharidatum, . . .	Cantharides Cerate, 80 Gm.; Burgundy Pitch, to make 1000 Gm.

PLASTERS—SPREAD.

Emplastrum Capsici, ...	Oleoresin of Capsicum; Resin Plaster.
" Ichthyocollæ, .	Isinglass, 10 Gm.; Alcohol, 40 Gm.; Glycerin, 1 Gm.; Water, and Tincture of Benzoin, each, sufficient quantity.

CHARTÆ—(*Medicated Papers*).

The official Papers consist of paper saturated or covered with medicinal substances.

The Pharmacopœia recognizes only two of these medicated papers.

CHARTA POTASSII NITRATIS.—This consists of white unsized paper saturated with a solution of potassium nitrate. It is employed in cases of asthma, by burning it, and inhaling the smoke. It is often saturated with fluid extract of belladonna or of stramonium.

CHARTA SINAPIS.—The fixed oil present in the black mustard is first removed by percolating with benzin. The solution of india rubber serves as an adhesive coat, firmly retaining the powder. The irritating properties of the powdered black mustard depend upon the generation of a vesicating volatile oil, which takes place when the powder is moistened with water. This volatile oil is formed through the decomposition of a glucoside called *sinigrin* (potassium myronate), caused by the influence of an albuminous ferment *myrosin*, which does not enter the reaction itself; the reaction being thus:—

$$\underset{\substack{\text{Sinigrin.}\\\text{(Potassium}\\\text{Myronate).}}}{C_{10}H_{18}KNS_2O_{10}} = \underset{\substack{\text{Allyl Sulphocyanate}\\\text{(Oil of Mustard).}}}{C_3H_5CNS} + \underset{\substack{\text{Acid Potassium}\\\text{Sulphate.}}}{KHSO_4} + \underset{\text{Glucose.}}{C_6H_{12}O_6}$$

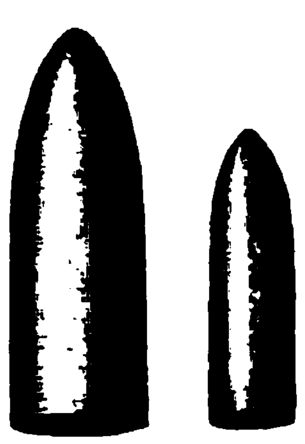
Hot water causes coagulation of the albuminous ferment, hence no oil will be produced; only lukewarm or cold water should be used to moisten the drug.

SUPPOSITORIA—(*Suppositories*).

Suppositories are suitably-shaped masses of medicated fats, which readily fuse when introduced into the body.

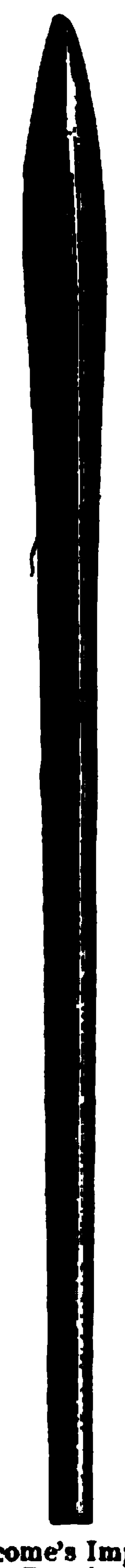
According to their size and shape, there are three forms, namely, the *Rectal* (cone-shaped) which should weigh about one gramme (U. S. P.), but which may also be made to weigh as much as two grammes; the *Urethral* (pencil-shaped) should weigh about one gramme (U. S. P.); the *Vaginal* (globular or cone-shaped) should weigh about three grammes (U. S. P.), but may also be made to weigh over four grammes.

FIG. 370.



Suppositories (Rectal).

FIG. 372.



Wellcome's Improved Bougie.

Suppositories are sometimes given a double cone-shape, that is, pointed at both ends. The usual cone- and double cone-shaped suppository is sometimes difficult of retention, because of the peculiar contraction of the sphincter muscles; in view of this, Wellcome (August, 1893) suggested a modification of their shape, which, allowing the introduction of the bulbous end first, ensures perfect retention, by the reflex contraction of the sphincter.

FIG. 371.

Wellcome's Improved Suppository.

The vehicle employed should be of such consistence as to retain its shape at the ordinary temperature, yet it should be sufficiently soft not to produce any injury on insertion, and readily fuse at the temperature of the body. It should not become rancid and yet be capable of being mixed with most medicinal substances without any lowering of its fusing point.

The various bases employed may be designated as *fatty* (cacao butter), *saponaceous* (curd soap from animal fat), and *gelatinous;* neither of the latter, however, give the general satisfaction that is obtained from the use of cacao butter.

THE GELATIN BASE.—This forms a valuable and serviceable substitute where objections are made to a fatty basis. Accord-

ing to theory, it is not adapted for administering tannic acid, since they are supposed to form an insoluble compound. These gelatin suppositories are more readily made than those of cacao butter, but present the difficulty of lacking firmness. They are made by moulding. For this purpose the moulds must be thoroughly cleaned and dried, then wiped inside with a piece of flannel impregnated with oil. The base is fused in a capsule on a water-bath, the medicinal ingredients dissolved in a little water and stirred in until thoroughly diffused or dissolved. When of proper degree of consistence the mass is poured into well cooled moulds.

The same mass is not applicable to all medicaments, since some render it too hard, others too soft. The gelatin base may be kept almost indefinitely, provided it is poured into bottles and, when cold, covered with alcohol.

The following gelatin bases* have been proposed:—

I. Gelatin 10 parts, water 40 parts, glycerin 15 parts; evaporate to 25 parts. This combination is suitable for hygroscopic drugs, for bougies containing ferric chloride (dissolve 1 part of ferric chloride in 9 parts of water and add to 19 parts of the mass), for tannin suppositories (0.2 per cent.,—not in accordance with theory), and for vaginal pessaries containing such salts as potassium iodide or bromide, sodium bromide or salicylate, ergotin, chloral hydrate, etc.

II. Gelatin 10 parts, water 40 parts, glycerin 20 parts; evaporate to 50 parts. A good base for general use. Phenol or such substances as are soluble in alcohol are first dissolved in a little alcohol, added to 7 parts of glycerin and 50 parts of this mass. Alum bougies are made by adding a hot solution of 7 parts of alum in 10 parts of glycerin, and 5 parts of water to 25 parts of the mass liquefied on a bath with 10 parts of water. The whole is evaporated, under stirring, to 35 parts.

III. Gelatin 10 parts, water 40 parts, glycerin 30 parts; evaporate to 60 parts. This mass is adapted as a vehicle for such substances as cupric or zinc sulphate, silver nitrate, extract of opium, mercuric chloride, etc.

IV. Gelatin 30 parts, water 120 parts, glycerin 15 parts; evaporate to 104 parts. A basis for bougies containing a large percentage of insoluble drugs. Iodoform bougies (50 per cent.) are made by adding 27 parts of pulverized iodoform to 27 parts of the mass.

For a glycerin suppository,† the following has been recommended; glycerin 10 parts, water 5 parts, gelatin 1 to 2 parts; in order to render the suppositories sufficiently firm, it has been recommended to dip them into melted cacao butter.

Cacao Butter Suppositories.—According to their method of

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* C. H. Ochse, "Art of Dispensing," *Chemist and Druggist*, London.

† This was proposed previous to the appearance of the U. S. P. of 1890, in which "Suppositoria Glycerini," made by another process, were made official.

preparation they may be designated as *hand-rolled, moulded,* and *compressed.*

Hand-rolled.—The method of forming by hand is very simple, the operation being carried out much in the same manner as that of making a pill mass. The Cacao butter is grated and weighed; the medicinal agents are reduced to a fine powder in the mortar, or, if they consist of extracts, they should be moistened with a little water and rubbed to a smooth paste; to this is added the cacao-butter and the whole thoroughly incorporated and beaten into a pill mass. In order to impart plasticity, a few drops of castor or olive oil are often added. The mass is then rolled out on a pill tile into a cylinder of the desired thickness and length, finely powdered starch being employed as dusting powder. The cylinder is then divided into the necessary number of parts, and by carefully rounding one end by rolling on the tile with the spatula or by forming between the fingers, the desired shape is imparted.

The hands and all utensils must be kept scrupulously clean. A rusty spatula or a poorly cleansed tile is sufficient to ruin the appearance of the most carefully made suppository.

Sometimes, through lack of adhesiveness, the mass crumbles when rubbed. It should then be worked over in the mortar with addition of a drop or two of oil if necessary, and formed into a cylinder with the hands, with sufficient rapidity to avoid undue softening of the mass. Also care should be taken not to incorporate too much of the dusting powder in the operation of rolling out the cylinder, otherwise the mass will crumble, from lack of adhesiveness.

Moulded Suppositories.—The directions of the Pharmacopœia are as follows:—

Take of

The Medicinal Ingredient, *the prescribed quantity.*
Oil of Theobroma, *a sufficient quantity.*

Having weighed out the medicinal ingredient or ingredients, and the quantity of Oil of Theobroma required, according to the kind of Suppository to be prepared, mix the medicinal portion (previously brought to a proper consistence, if necessary) with a small quantity of the Oil of Theobroma, by rubbing them together, and add the mixture to the remainder of the Oil of Theobroma, previously melted and cooled to the temperature of 35° C. (95° F.). Then mix thoroughly, without applying more heat, and immediately pour the mixture into suitable moulds. The moulds must be kept cold by being placed on ice, or by immersion in ice-cold water, before the melted mass is poured in.

In the absence of suitable moulds, Suppositories may be formed by allowing the mixture, prepared as above, to cool, care being taken to keep the ingredients well mixed, and dividing the mass into parts, of a definite weight each, of the proper shape.

Unless otherwise specified, Suppositories should have the following weights and shapes, corresponding to their several uses:—

Rectal Suppositories should be cone-shaped, and of a weight of about *one* (1) *gramme.*

Urethral Suppositories should be pencil-shaped, and of a weight of about *one* (1) *gramme.*

Vaginal Suppositories should be globular, and of a weight of about *three* (3) *grammes.*

Insoluble substances, when forming the constituents of a suppository, should be reduced to a very fine powder; solid extracts should be rubbed with sufficient water to form a smooth paste. This latter point should be carefully observed, because the solanaceous extracts generally contain numerous minute crystals of potassium nitrate and chloride, which prove very irritating when allowed to remain in crystalline condition.

Care should be taken not to heat or to continue heating the melted mass after the medicinal ingredients are added, otherwise they will separate in a solid mass from the fused fat. The medicinal ingredients are simply in a state of suspension, hence they should be added just before the mass cools, when the cacao-butter is of a syrupy consistence; after these have been added, the mass should be constantly and vigorously stirred, while it is poured into the moulds, otherwise the medicinal constituents will be unevenly distributed, the last suppository receiving more than the others.

The moulds should be as cold as possible, so as to secure rapid congelation of the mass, thereby preventing the heavier particles from settling to the bottom.

If the moulds are properly cleansed and cooled, the suppository will shrink sufficiently to enable the operator to remove it without any difficulty, hence there is no occasion for the use of dusting powder. Some operators prefer to wipe out the moulds with a piece of flannel moistened with soap liniment.

MOULDS.

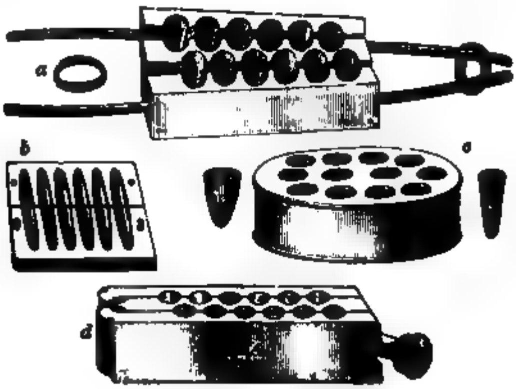
The simplest moulds may be made by rolling glazed or waxed paper into cones of the proper size, placing them into sand or supporting them in holes made in a cardboard box.

Among the older forms of moulds are those made of white metal (Fig. 373, *c*), which are supported in perforations in the lid of a tin box filled with crushed ice or snow. The suppositories are removed from these moulds by inverting them and tapping; after the moulds have been in use some time, which renders them rather difficult to clean properly, particles of the mass are apt to remain adhering to the inside, which tends to interfere with the subsequent removal of the suppositories.

The moulds *a* and *b* (Fig. 373), are improvements over the first-

named form in that they are composed of two distinct parts, which greatly facilitates the removal of suppositories and the subsequent cleaning of the mould. In the form shown in *b*, the two halves are held in position by means of a rubber band; while in the Wirz mould (Fig. 373, *a*), the halves are held firmly in position by rings, which are slipped over the handles. The so-called hinged, double

FIG. 373.



Suppository Moulds.

mould of gun metal (Fig. 373, *d*), because of its compactness and the close fitting of its parts, is one of the most convenient forms made; this is usually so constructed as to accommodate two different sizes of suppositories. The moulds shown in Figs. 374 and 375 are constructed on this same principle, but instead of

FIG. 374. FIG. 375.

Sée's Suppository Mould. Blackmann's Suppository Mould.

opening perpendicularly, as the others, they open horizontally. These forms of moulds have the advantage of size and compactness of shape. After the mass has been poured into the mould, ample time should be allowed for the suppositories to contract; then, if on pressing them slightly on top they show that they are

sufficiently loose, the upper half or inside ring of the mould should be carefully detached by raising it equally on all sides, otherwise there would be danger of fracturing the suppositories.

Compressed Suppositories.—The preparation of suppositories by the process of melting and moulding is at present being supplanted by the method of cold compression. This possesses not only the advantage of rapidity, but also yields a perfect, compact suppository at all times without the use of ice. As before stated, some organic bodies, for instance chloral, creosote, phenol, volatile oils, etc., when warmed with cacao-butter, influence its melting-point to such a degree that the mass refuses to harden. This difficulty also arises when they are made cold by hand.

Among the earlier forms of these cold-pressure moulds is that devised by Archibald. This is operated by placing the mixture of grated cacao-butter and medicinal substances in a hopper, where the mass is then forced by means of a plunger, operated by a handle-lever, into the mould below. The objection to this form of apparatus is that the removal of the suppositories from the mould is necessarily slow and attended with difficulty. Moreover, in order to avoid the fracture of the suppositories, the moulds must be kept very cold and well greased or dusted, so as to prevent the mass from adhering to the sides. The necessity of filling the hopper each time is also not a point in favor of this apparatus.

These difficulties have all been overcome in the later forms, which are based on the principle of forcing the entire mass, contained in a cylinder, under a powerful pressure, by means of a plunger operated by a screw, through small apertures in the bottom of the brass mould secured into the end of a cylinder; the end of the mould resting against a movable plate.

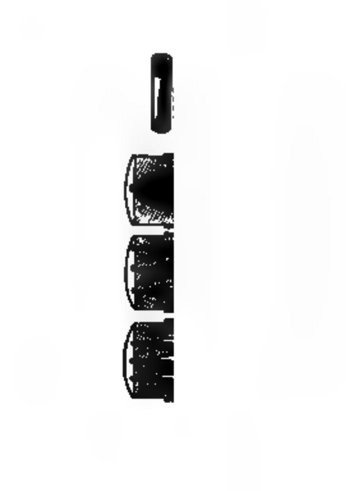
One of the older forms constructed on this principle is the mould made by Mr. Knowlson of Troy, N. Y. A later machine of similar construction is shown in Figures 376 and 377.

This consists simply of a cylinder swinging in a frame, in which the mould is placed with the small holes up. The mass, previously prepared, is thrown into this cylinder, which at this time is open, as in Fig. 376. The cylinder is then closed, and the screw pressure is applied until all resistance is overcome. Before opening the bed-plate, the screw should be loosened by half a turn, then the bed-plate thrown back (see Fig. 377) and the screw again gently turned downward until the suppositories drop out. After these are secured, the bed-plate is closed and the operation repeated, until the cylinder is emptied of the mass. The small cylindrical pieces which force the suppositories from the moulds, should, of course, be returned to the cylinder at the last working, for conversion into suppositories.

In making Urethral or Nasal Suppositories, remove the cap at No. 2, Fig. 377, and screw on the small tube, taking care to have a mould in the cylinder covered with a brass disc, which is

furnished. The mass is then simply put into the cylinder as before, pressure applied, and the suppositories cut into any length desired.

FIG. 376. FIG. 377.



Perfection Suppository Machine.

When Suppositories are ordered, it is at the option of the Pharmacist to employ either cacao butter, grated on a lemon grater,

FIG. 378.

Suppository Machine.

with the extracts in a state of powder, and by means of a slab and spatula to thoroughly incorporate the cacao and extracts together, then to throw the material into the cylinder and to use the screw; or he may take the cacao butter as ordinarily sold in

the market, and work it in with the extracts in the same manner that a pill mass is made, taking care to thoroughly diffuse the active ingredient, and when they are thoroughly mixed to throw the mass into the cylinder, and to operate the screw to compress the suppository.

Another new machine is illustrated in Fig. 378. This is of simple construction and easily and quickly operated.

Each machine is furnished with a set of moulds for making suppositories of three sizes—15-grain, 30-grain, and vaginal—and with a mould for forming bougies. These moulds are of brass and are screwed into the end of the cylinder. They can be easily and rapidly inserted or removed.

In making suppositories the cacao butter mixed with the medicinal substance is placed in the cylinder, the mould required being first attached, and the cylinder is put in position with the end of the mould resting against the movable plate at the end of the machine. The mass is then compressed in the forms by turning the wheel and screwing the plunger into the cylinder. After the suppositories are formed, the end plate is removed, and a further turn of the wheel forces them out upon the tray. The operation is then repeated until all the mass has been used.

By a special device, the screw on the plunger rod may be released so that the plunger may be pushed into the cylinder or withdrawn from it without the slow process of screwing.

FIG. 379.

Bougie Press.

BOUGIES are solid cylindrical rods of 2 to four millimeters diameter and from 7 to 15 centimeters long, pointed at one end and weighing about one gramme. These are formed by hand, or in special moulds or may be made by cold pressure (Fig. 379). In the absence of moulds they may be moulded by pouring the mass into glass tubing of the proper size (oiled inside). When cold, they are forced out by means of a glass rod, then cut into pieces of the desired size, and pointed at one end. Owing to the brittle nature of the cacao butter,* they are generally made of gelatin. H. Helbing † recommends the following:—

" *Gelatin Mass* is best prepared from 10 oz. best gelatin, 16 oz.

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* The following formula is proposed by N. Pritzker:—

Cacao butter,	grains	480
Powd. acacia.	"	240
Water,	min.	240
Glycerin,	"	120
Powd. boric acid sufficient.		

Melt the cacao butter and triturate it in a warm capsule with the acacia, and add the water previously mixed with the glycerin; place the capsule in cold water or on ice until the mass has solidified, and set the vessel aside. When required for use, take of the above four drachms, incorporate it with the medicaments and with from 10 to 25 per cent. cacao butter, triturate until intimately mixed, and roll out into 10 bougies.

† Proceed. Amer. Phar. Ass'n., 1889, p. 402.

best glycerin, and sufficient water. The gelatin is dissolved in sufficient water and the glycerin by the aid of a water-bath in a porcelain dish, the water lost by evaporation being compensated for by the addition of more. The ingredients, if not soluble in water, are mixed in a finely powdered condition with the warm and tenacious glue, and the pencils are moulded in moulds similar to those used for making caustic, previously moistened with oil or soap liniment. When cold they are quite elastic, but not sticky.

"*Iodoform Pencils*, 33 *per cent.*—Iodoform, 1 part; cacao butter, 2 parts.

"*Cocaine Pencils*, 2 *per cent.*—Cocaine hydrochlorate, 1 part; cacao butter, 49 parts. To be cut in pieces containing $\frac{1}{8}$ grain of the cocaine salt each.

"*Salol Pencils*, 20 *per cent.*—Dissolve 1 part of salol in 4 parts of the liquefied cacao butter, stir constantly until cool, powder the mass, and form cylinders by the aid of the press.

"*Opium Pencils*, 5 *per cent.*—Powdered opium, 1 part; cacao butter, 19 parts. Divide into sticks containing 1 grain of opium each.

"*Thallin Pencils*, 5 *per cent.*—Sulphate of thalline, 1 part; cacao butter, 19 parts.

"*Mercurial Pencils*, 25 *per cent.*—Made with equal parts of mercurial ointment and white wax, previously melted. When cool the pencils are pressed out. The following elastic pencils may be made with a mass containing tragacanth, starch, etc.:—

"*Iodoform Pencils*, 33 *per cent.*—Iodoform, ʒj; starch, ʒiij; tragacanth, ʒj; dextrin, ʒj; sugar, ℥ss; water and glycerin, each sufficient.

"*Salicylic Acid Pencils*, 5 *per cent.*—Salicylic acid, ʒj; tragacanth, ʒj; starch, ʒj; dextrin, ʒvij; sugar, ʒiij; water and glycerin, each sufficient. These pencils may be polished, if desirable, by rolling them on a porcelain slab with a thin board.

"*Urethral Pencils.*—Urethral pencils, retaining their shape for some hours, are prepared from cacao butter, 6; beeswax, 5; boric acid (or iodoform, etc.), 2; zinc oxide, 1; and tragacanth, 4 parts. These pencils possess a certain degree of elasticity, and are prepared of a conical form.

"*Caustic Pencils*—Dr. De Sinéty's.—Crystallized phenol, 0.05 Gm.; tannin, 4.0 Gm.; glycerin, 5 drops; tragacanth sufficient."

FIG. 390.

Gelatin Suppository Capsules.

SUPPOSITORY CAPSULES.—These consist of gelatin shells which are filled with the medicinal substance, or with a mixture of it and cacao butter. The upper and outer margin of the lower half is moistened with water and the cap slid over it, so as to prevent the two halves from coming apart in handling. Before they are inserted, they should be dipped in water so as to enable them to slip in easily.

Hollow Cacao Butter Suppositories.—These are very convenient for the dispenser and answer quite well when the medicating ingredient is of a neutral nature, but they should *never* be used when the remedy is in any degree locally irritating. The main object of employing an excipient (cacao butter or gelatin)

Fig. 381.

Hollow Cacao Butter Suppositories.

in a suppository is to secure slow and uniform diffusion of the remedy. The medicinal substance should be well mixed with a little grated cacao butter before it is filled into the cavity, which is then closed by the plug provided for this purpose.

Fig. 382.

Hollow Cacao Butter Suppositories.

GENERAL REMARKS.

Suppositories are usually dispensed in partitioned paper boxes, or in wide-mouthed vials. The practice of wrapping them in paraffin paper or foil is not advisable, owing to the possible

ignorance of many patients, who might use them without removing the wrapper.

As in the case of pill masses, the medicinal ingredients should always be thoroughly incorporated with the mass before it is moulded.

When such heavy salts as potassium iodide or bromide, or lead acetate are directed to be incorporated in suppositories, they should be made by hand or by cold compression. For, when they are made by the process of fusion, even with the greatest of care and skilled manipulation, the salts, owing to their gravity, will settle and collect at the point of the suppository, which is not only disagreeable but may be dangerous to the patient. For this class of remedies, the gelatin basis is the most advantageous, since the inorganic salt may previously be dissolved in a portion of the water.

When iodine is directed to be incorporated in a suppository it should be first powdered with a little potassium iodide, then dissolved in a small amount of water and added to the gelatin basis.

Alkaloids (that is, free alkaloids), should be dissolved in a little oleic acid before being combined with the cacao butter.

Green extracts and tannin. When such extracts as those of belladonna, stramonium or hyoscyamus are prescribed with tannin, the suppositories should be made by cold pressure. It is possible, with due care, to prepare these by the warm process; the extract, after having been reduced to a smooth paste with a little water, is combined with the melted fat, then, when the mass is sufficiently cool and ready to pour, the tannin is quickly stirred in. But the slightest degree of overheating causes the tannin to unite with the extract, forming hard lumps.

Wax, owing to its high fusing point, should never be added to a suppository mass in any quantity.

Suppositoria Glycerini, U. S. P.—This is the only official suppository. It is made by heating stearic acid, glycerin, and sodium carbonate together until effervescence ceases, then pouring into moulds. The reaction that takes place results in the formation of sodium stearate, a very hard soap:—

$$\underset{\text{Stearic Acid.}}{2HC_{18}H_{35}O_2} + \underset{\text{Sodium Carbonate.}}{Na_2CO_3} = \underset{\text{Sodium Stearate.}}{2NaC_{18}H_{35}O_2} + \underset{\text{Water.}}{H_2O} + \underset{\text{Carbon Dioxide.}}{CO_2}$$

This with the large amount of glycerin present (90 per cent.) forms a firm, stable suppository.

According to Thumann * these may also be made from cacao butter rendered liquid at 35° C. and agitated with an equal weight of warmed glycerin (50 per cent.) until the mixture begins to solidify, when it is poured into moulds.

Owing to the hygroscopic nature of these glycerin suppositories, they should be dispensed in wide-mouthed vials or glass tubes which are securely corked and sealed.

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* *American Journal of Pharmacy*, 1893, p. 368.

PART III.

THE ART OF DISPENSING.

CHAPTER XXXVI.

THE PRESCRIPTION.

A prescription is a written formula of remedies, with directions to the apothecary for their preparation, and instructions for the guidance of the patient or of his attendant.

The word prescription is derived from the Latin word *præscriptio*, title; order; ordinance, etc., from *præscribo* "to write before; to ordain."

For writing prescriptions, the Latin language is almost universal, because, being a language of science, it is generally understood in civilized countries. And being a dead language, it is not subject to the various changes peculiar to modern tongues.* Moreover, for various reasons, it is not advisable, as a rule, that the patient be aware of the kind and nature of the remedies administered.

The prescription consists of the following parts, thus classified:—

(1) **The Superscription, ... ℞.**
(2) **The Inscription, ... Remedy (genitive) ; Quantity (accusative).**
Repeat for each constituent.
(3) **The Subscription, ... Misce (directions to compounder).**
(4) **The Signature, ... Signa (directions for the patient).**
(5) **This is generally followed by the name of the patient, † and always by the name or initials of the prescriber. with date.**

1st. THE SUPERSCRIPTION (*superscribo* = to write on top) or HEADING.

The symbol ℞ is usually placed at the head of every prescription.

The letter R stands for the Latin word *Recipe*, the imperative mood of the verb *recipio*, "*to take*." When the prescription is written in English, this letter R is replaced by the words "take of"; in French, it would be replaced by a P (abbreviation for *prenez*, take); in German, it would be replaced by the word "nimm" (take).

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* Vernacular names in various languages may vary in different parts of the same country, and are often unintelligible to foreigners. Hence a prescription written in the native language in one part of the country may be unintelligible in another part.

† Also written in the upper corner of the prescription.

The sign ℞, according to some, is derived from the symbol ♃, the zodiacal sign for the planet Jupiter. In ancient times, it was customary to invoke the blessings of the deity, Jupiter or others, on the remedies to be taken, by a formal prayer at the beginning of the prescription. This was, in time, contracted to simply placing the sign of the respective deity addressed at the head of the prescription.

2d. THE INSCRIPTION (*inscribo* = to write upon). This includes the names and quantities of the various ingredients. These ought to be arranged, if possible, in a definite manner, somewhat after the following plan:—

The Basis—the principal active agent.

The Auxiliary (adjuvant)—the ingredients which aid or promote the action of the Basis. For example, the combination of chloral and potassium bromide, is more certain as an hypnotic than either alone, hence, while chloral is placed first, potassium bromide follows as an auxiliary. With cathartics, the auxiliary, while assisting the action of the base, renders it more manageable, lessening its liability to irritate, as for example the adjuvant Myrrh, when combined with Aloes. In conjunction with Quinine, the adjuvants Capsicum and Opium are often prescribed for breaking up intermittent fevers.

The Corrective.—The ingredient which corrects or modifies the action of the first. For example, the griping tendency of many purgatives is usually overcome by combining them with aromatics.

The Vehicle (excipient and diluent).—The ingredient which assists in imparting proper form, and also in diluting the active constituents.

Example.

℞. Aloes Purificatæ,	2 Gm.	(*base*).
Myrrhæ,	1 Gm.	(*adjuvant*).
Pulveris Aromatici,	5 Gm.	(*corrective*).
Extracti Gentianæ,	q. s.	(*excipient*).

Fiat massa ; divide in pilulas xvi.

or

℞. Quininæ Sulphatis,	gr. xx	(*base*).
Ferri et Ammonii Citratis,	gr. xl	(*adjuvant*).
Acidi Citrici,	gr. x	(*excipient*).
Syrupi Limonis,	fl ℥j	(*vehicle*).
Aquæ puræ,	q. s. ad. fl ℥ij	(*diluent*).

Misce.

GRAMMATICAL CONSTRUCTION.*

The following example is selected as an illustration of Latin construction, as applied in prescriptions:

* Only the briefest outlines can be given here. The reader is referred to special text-books, such as Robinson's Latin Grammar, or "The Prescription," by Wall. Consult, also: "The Latin Grammar of Pharmacy;" by Joseph Ince, London.

℞. Quininæ Sulphatis, ... drachmam unam (ʒj)
Tincturæ Cinchonæ Compositæ, ... uncias duas (℥ij)
Glycerini, ... unciam unam et semissem (℥iss)
Acidi Sulphurici Diluti, ... quantum sufficiat (q. s.).
Aquæ, ... q. s. [quantum sufficiat] ad uncias quatuor (ad ℥iv).

Recipe;	*Quininæ*	*Sulphatis*	*drachmam*	*unam.*
Take thou	of Quinine	Sulphate	drachm	one.

℞ is the symbolic abbreviation for *recipe*, the imperative mood of the active verb, *recipio, recepi, receptum* (3d conjugation), meaning "to take;" its object is *drachmam*, the accusative singular of *drachma, æ; unam* is the accusative singular of the adjective *unus, a, um*, which agrees with *drachmam*. Thus we have, "take one drachm,"—of what? of *sulphate of quinine*. This is put in Latin in the genitive (possessive case in English); *sulphatis* is the genitive of *Sulphas; quininæ* is the genitive of *Quinina*.

Recipe	*Tincturæ Cinchonæ Compositæ*	*uncias*	*duas.*
Take	of Compound Tincture of Cinchona	ounces	two.

Uncias is the accusative plural of *uncia, æ*, governed by recipe. *Duas* is the accusative plural (fem.) of the numeral adjective, *duo, æ, o*, and agrees with *uncias*.

Tincturæ, noun feminine, genitive, depending on *uncias*, from *Tinctura, æ*.

Cinchonæ, noun feminine, genitive, depending on *tinctura*, from *Cinchona, æ*.

Compositæ, adjective, feminine, genitive, (from *compositus, a, um*), agreeing with *tincturæ*. (The tincture is a "compound tincture.")

Recipe	*Glycerini*	*unciam unam et semissem.*
Take	of Glycerin	ounce one and a half.

Glycerini is the genitive of the neuter noun *glycerinum,-i*, depending on *unciam*.

Unciam is the accusative singular of the feminine noun *uncia, æ*, governed by *recipe*.

Unam, a numeral adjective, accusative singular, agreeing with *unciam*.

Et, is the conjunction "and."

Semissem, the accusative singular of *semis*, gen. *semissis*, a noun (masc.) meaning "a half part."

Recipe	*Acidi Sulphurici*	*Diluti,*	*quantum sufficiat.*
Take of	Acid Sulphuric	Dilute,	as much as may suffice.

Quantum, accusative singular neuter of the interrogative and correlative pronoun *quantus, a, um*, "how great, how much;" the neuter standing here for a noun, "how great a thing." There is to be supplied, as object of the verb "*recipe*," the demonstrative pronoun *tantum*, "so much: *recipe* [*tantum*] *quantum*

sufficiat, "take [so much] how much may suffice" = "take as much as may suffice."

Sufficiat, third person, singular, present subjunctive, of *sufficio, suffeci, suffectum* (3d conj.), "to suffice."

Acidi, genitive singular of *Acidum, i*, "the acid."

Sulphurici, genitive singular of the adjective *sulphuricus, a, um*, "sulphuric," agreeing with *Acidi*.

Diluti, genitive singular of the adjective *dilutus, a, um*, "diluted," also agreeing with *Acidi*.

Recipe	*Aquæ*	*ad*	*uncias*	*quatuor.*
Take	of water	to	ounces	four.

Aquæ is genitive singular of *aqua, æ*, "water." The genitive depends on a word (*tantum*) which must be supplied mentally (see below).

Ad, preposition with accusative, "to, up to."

Uncias, accusative plural of *uncia, æ*, "ounce."

Quatuor, indeclinable numeral, "four."

The sentence is curtailed, since there is apparently no object (accusative) dependent on *recipe*. In its complete form, the sentence would be: *Recipe tantum aquæ quantum sufficiat ad uncias quatuor*, "take as much water as [much] would be sufficient up to four ounces."

It is rare that the names of the various ingredients are ever written out in full in a prescription, abbreviation being almost a necessity. This should, however, be carefully and considerately done, for such abbreviations can in some instances give rise to serious errors. As examples, a number of such misleading abbreviations are given here :—

	May be taken for
Acid. Hydroc.	Acidum Hydrochloricum. " Hydrocyanicum.
Aq. Chlor.	Aqua Chlori. " Chloroformi.
Calc. Chlor.	Calcii Chloridum. Calx Chlorata.
Chlor.	Chlorum (Chlorine). Chloroform. Chloral Hydrate.
Ext. Col.	Extractum Colchici. " Colocynthidis.
Hyd. Chlor.	Calomel. Corrosive Sublimate. Hydrate of Chloral.
Hyd. or Hydr.	Hydrargyrum (Mercury). Hydras (Hydrate). Hydrochlorate. Hydrocyanate, etc.
Pot. Chlor.	Potassium Chlorate. " Chloride.
Pot. Sulph.	Potassium Sulphate. " Sulphite. " Sulphide.

	May be taken for
Sod. Hypo.	Sodium Hypophosphite. " Hyposulphite.
Sod. Sulph.	Sodium Sulphate. " Sulphite. " Sulphide.
Zinc Phos.	Zinc Phosphate. " Phosphide.

The *quantity* of the various ingredients is very seldom written in full, except perhaps occasionally in metric prescriptions, but is expressed by the various appropriate signs, thus:—

WEIGHTS.

The Ounce (troy), .	Symbol	℥	Latin	Uncia	(480 grains).
The Drachm, . .	"	ʒ	"	Drachma	(60 grains).
The Scruple, . . .	"	℈	"	Scrupulum	(20 grains).
The Grain, . . .	"	gr.	"	Granum.	

MEASURES.

The Pint, . .	Symbol	O	Latin	Octarius (16 fluidounces).
The Fluidounce,	"	f℥	"	Fluiduncia.
The Fluidrachm,	"	fʒ	"	Fluidrachma (60 minims).
The Minim, . .	"	♏	"	Minimum ($\frac{1}{60}$ of a fluidrachm).
A half, ...	"	ss or s̸s̸	"	Semis.

Doses.—The doses given in the text-books are either the maximum and minimum, or the average quantity necessary to produce the full effect of the remedy on a healthy adult. These must be diminished for children, females or aged persons, or in other special cases. For children, the dosage may be regulated according to the rule of Dr. Young, viz.: "Divide the age of the child, in years, by the age of the child plus twelve." For example, if the age is 6 years, the dose would be $\frac{6}{6+12} = \frac{6}{18} = \frac{1}{3}$ the dose for a child of six years is, therefore, *one-third* of that for an adult.

Dr. Cowling's rule is, "to add 1 to the age of the child in years and divide by 24." For example, if the age is 5 years, add 1 which makes 6, and divide by 24, which gives $\frac{6}{24}$ or $\frac{1}{4}$. Hence the dose for a child aged 5 years would be *one-fourth* of that for an adult.

3d. THE SUBSCRIPTION.—This includes special instructions to the dispenser for compounding. Since the modern apothecary is presumed to be sufficiently educated to deal with all sorts of combinations, the physician, as a rule, contracts the directions to a word or even a letter, thus: M. (*misce*), S. (*solve*), F. (*fiat*).

Example:—

℞. Morphinæ hydrochloratis, ... gr. iij
Sacchari albi pulveris, ... ʒ iij.

M (*isce*).	F(*iat*)	p(*ulvis*);	d(*ivide*)	i(*n*)	p(*artes*)	æq(*uales*)	n(*umero*)	*xx*
Mix.	Let be made	powder;	divide	into	parts	equal	by number	20

4th. THE SIGNATURE (*signatura* = label).—The directions for the patient are frequently abbreviated and usually begin with "Sig." or "S." (= *signa*, imperative of the verb *signo*, "to mark; to label"); sometimes with: "Misce, detur cum signatura, . . . " (mix; let it be given with the directions. . . . .).

Among American physicians, the directions are rarely given in Latin, to avoid any possibility of misinterpretation; also for the sake of the patient, who should fully understand the directions. Hence they are usually written in full, and explicitly, in plain English.

5th. Following the instructions for the patient, the physician signs either his name or initials, with date. The name of the patient should always be written in the upper or lower corner of the prescription, in order to avoid any error on the part of the dispenser or the patient.

LATIN TERMS AND ABBREVIATIONS OFTEN USED IN PRESCRIPTIONS.

WORD OR PHRASE.	USUAL CONTRACTION.	MEANING.
Ad,		To, or up to.
Ad duas vices,	Ad 2 vic.	At twice taking.
Ad secundam vicem,	Ad sec. vic.	For the second time.
Ad tertiam vicem,	Ad 3 tiam vic.	For the third time.
Adde,	Add.	Add.
Addantur,	Add.	Let (them) be added.
Addendus,	Add.	To be added.
Adhibendus,	Adhib.	To be administered.
Ad libitum,	Ad lib.	At pleasure.
Admove,	Admov.	Apply.
Admoveatur,	Admov.	Let (it) be applied.
Agitato vase,	Agit. vas.	The vial being shaken.
Aliquot,	Aliq.	Some.
Alter,	Alt.	The other.
Alternis horis,	Alt. hor.	Every other hour.
Alvus,	Alv.	The belly.
Amplus,	Amp.	Large.
Ampulla,	Ampul.	A large bottle.
Ana,	A, or aa, or āā.	Of each.
Aqua,	Aq.	Water.
Aqua bulliens,	Aq. bull.	Boiling water.
Aqua communis,	Aq. com.	Common water.
Aqua fervens,	Aq. ferv.	Hot water.
Aqua fluvialis,	Aq. fluv.	River water.
Aqua fontana,	Aq. font.	Spring water.
Aqua pluvialis,	Aq. pluv.	Rain water.
Aut,		Or.
Bene,		Well.
Bibe,	Bib.	Drink (thou).
Biduum,	Bid.	Two days.
Bis,		Twice.
Bis in die, or *bis in dies,*		Twice a day.
Bolus,	Bol.	A large pill.

LATIN TERMS AND ABBREVIATIONS OFTEN USED IN PRESCRIPTIONS.—*Continued.*

Word or Phrase.	Usual Contraction.	Meaning.
Bulliat or *Bulliant*, . . .	Bull.	Let boil.
Calefactus, ...	Calef.	Warmed.
Caute, ...		Cautiously.
Cape, ...	Cap.	Take (thou).
Capiat, ...	Cap.	Let him take.
Capsula, ...	Capsul.	A capsule.
Charta, ...	Chart.	Paper.
Chartula, ...	Chartul.	A small paper.
Cibus, ...	Cib.	Food.
Cochlear, or *Cochleare*, . .	Coch.	A spoonful.
Cochleare amplum, ...	Coch. amp.	A dessertspoonful.
Cochleare magnum, . . .	Coch. mag.	A tablespoonful.
Cochleare parvum, ...	Coch. parv.	A teaspoonful.
Coctio, ...	Coct.	Boiling (noun).
Cola, ...	Col.	Strain.
Colaturæ (dative), ...	Colatur.	To the strained liquor.
Collutorium, ...	Collut.	A mouth wash.
Collyrium, ...	Collyr.	An eye wash.
Compositus,-a,-um, . . .	Comp.	Compounded.
Concisus,-a,-um, ...	Concis.	Cut.
Congius, ...	Cong.	A gallon.
Contusus,-a,-um, ...	Contus.	Bruised.
Coque; Coquantur, . . .	Coq.	Boil; let them be boiled.
Cortex, gen. *Corticis*, . . .	Cort.	The bark.
Cras (adv.); *Crastinus*, (adj), ...	Crast.	To-morrow.
Cras mane sumendus, . .		To be taken to-morrow morning.
Cras nocte, ...		To-morrow night.
Cujus, *Cujus-libet*, ...	Cuj.	Of which, of any.
Cum, ...	C.	With.
Cyathus, or *Cyathus vinarius*, ...	Cyath., C. vinar.	A wine-glass.
Da; detur, ...	D., det.	Give; let be given.
De, ...		Of, or from.
Decanta, ...	Dec.	Pour off.
Decem; Decimus, ...	Decem.	Ten; the tenth.
Dein, ...		Thereupon.
Deglutiatur, ...		Let be swallowed.
Dentur tales doses No. v, .	D. t. d. No. v.	Let 5 such doses be given.
Diebus alternis, ...	Dieb. alt.	Every other day.
Dilue; Dilutus,-a,-um, . .	Dil.	Dilute (thou); Diluted.
Dimidius,-a,-um, ...	Dim.	One-half.
Dividatur in partes æquales,	D. in p. æq.	Let it be divided into equal parts.
Dosis, ...	D.	A dose.
Drachma, ...	Dr. or ʒ.	A drachm (60 grains).
Eadem (fem.)	Ead.	The same.
Ejusdem, ...	Ejusd.	Of the same.
Emesis, ...		Vomiting.
Et, ...		And.
Extende, ...	Ext.	Spread.
Fac, ...	F.	Make.
Fiat, ...	Ft.	Let be made (sing.).
Fiat mistura, ...	Ft. mist.	Let a mixture be made.
Fiat pulvis et divide in chartulas no xii, ...	Ft. pulv. et div. in chart. xii.	Let a powder be made, and divide it into 12 papers.
Fiant, ...	Fnt., or Ft.	Let be made (pl.).
Fac pilulas duodecim, . .	F. pill. xii.	Make twelve pills.

LATIN TERMS AND ABBREVIATIONS OFTEN USED IN PRESCRIPTIONS.—*Continued.*

WORD OR PHRASE.	USUAL CONTRACTION.	MEANING.
Fervens,	Ferv.	Boiling.
Filtra,		Filter (thou).
Gargarisma,	Garg.	A gargle.
Gradatim,	Grad.	By degrees, gradually.
Gutta; Guttæ,	Gtt.	A drop; drops.
Haustus,	Haust.	A draught.
Hebdomas,	Hebdom.	A week.
Hora,	H.	An hour.
Idem,	Id.	The same.
In dies,	Ind.	Daily, or from day to day.
Inter,		Between.
Internus,-a,-um,	Int.	Inner or Internal.
Juxta,		Near to.
Lac, gen. *Lactis*,	Lac.	Milk, of Milk.
Lotio,	Lot.	A lotion.
Macera,	Mac.	Macerate.
Magnus,-a,-um,	Mag.	Large.
Mane,		In the morning.
Manus,	Manus.	The hand,
Mica panis,	Mic. pan.	Crumb of bread.
Minimum,	M. or min.	A minim.
Misce,	M.	Mix.
Mitte,	Mit.	Send.
Modicus,-a,-um,	Modic.	Middle-sized.
Modo præscripto,	Mod. præsc.	In the manner prescribed.
Non,		Not.
Non repetatur,	Non repetat.	Let it not be repeated.
Nox, gen. *Noctis*,		Night.
Numero,	No.	In number.
Omni hora,	Omn. hor.	Every hour.
Omni mane,		Every morning.
Omni nocte,		Every night.
Partitis vicibus,	Part. vic.	In divided doses.
Pastillus; Pastillum,	Pastil.	A pastille.
Per,		Through, By.
Pilula,	Pil.	A pill.
Poculum,	Pocul.	A cup.
Post Jentaculum,	Post jent.	After breakfast.
" *Prandium*,	Post prand.	After dinner.
Potus,		Drink (noun).
Præparatus,-a,-um,	Præp.	Prepared.
Primus,-a-um,	Primus.	The first.
Pro,		For.
Pro re nata,	P. r. n.	Occasionally.
Pulvis,	Pulv.	A powder.
Quantum libet,	Q. lib.	As much as is desired.
Quantum sufficiat,	Q. s.	As much as is sufficient.
Quaque (abl.),	Qq.	Each, or Every.
Quartus,-a,-um,	Quart.	Fourth.
Quatuor,	Quat.	Four.
Quinque,	Quinq.	Five.
Quintus,-a,-um,	Quint.	The fifth.
Quotidie,	Quotid.	Daily.
Recipe,	℞.	Take.
Reliquus,-a,-um,		Remaining.
Repetatur,	Rept.	Let it be repeated.
Saturatus,-a,-um,	Sat.	Saturated.
Scatula,	Scat.	A box.

LATIN TERMS AND ABBREVIATIONS OFTEN USED IN PRESCRIPTIONS.—*Continued.*

WORD OR PHRASE.	USUAL CONTRACTION.	MEANING.
Scrupulum, ...	Scrup., or ℈.	A scruple (20 grains).
Secundem artem, ...	S. A.	According to art.
Secundus-a,-um, ...	Second.	Second.
Semis, gen. *Semissis*, . . .	Ss.	A half.
Septem, ...	Sept.	Seven.
Sex, ...		Six.
Signa, ...	Sig.	Write, or Mark (thou).
Simul, ...		Together.
Sine, ...		Without.
Solve, ...	Solv.	Dissolve.
Somnus, ...	Somnus.	Sleep.
Statim, ...	Stat.	Immediately.
Sume, ...	Sum.	Take (thou).
Supra, ...		Above.
Talis, ...	Tal.	Such a one.
Ter, ...		Thrice, or Three times.
Ter in die, or *Ter die*, . .	T. i. d., or T. d.	Thrice daily.
Tere, ...		Rub (thou).
Tertius,-a,-um, ...	Tert.	Third.
Tres, ...		Three.
Triduum, ...	Trid.	Three days.
Tussis, ...	Tus.	A cough.
Ultimo præscriptus, . . .	Ult. præsc.	The last ordered.
Una, ...	Una.	Together.
Uncia, ...	Unc. or ℥.	An ounce.
Ut dictum, ...	Ut. Dict.	As directed.
Vas vitreum, ...	Vas vit.	A glass vessel.
Vel, ...		Or.
Vinum, ...	Vin.	Wine.
Vires (plus.), ...	Vir.	Strength.
Vitellus, ...	Vitel.	Yolk.
Vitreus,-a,-um, ...	Vitr.	Made of glass.

FOREIGN PRESCRIPTIONS.

German prescriptions offer some differences of nomenclature, particularly in the use of the adjective, thus:—

		From
℞. Kali hydrojodici, ...	5.0	(Kalium Hydrojodicum).
Aquæ camphoratæ, ...	50.0	(Aqua camphorata).
Syrupi, ...	120.0	(Syrupus).

Rendered into Anglo-Latin:

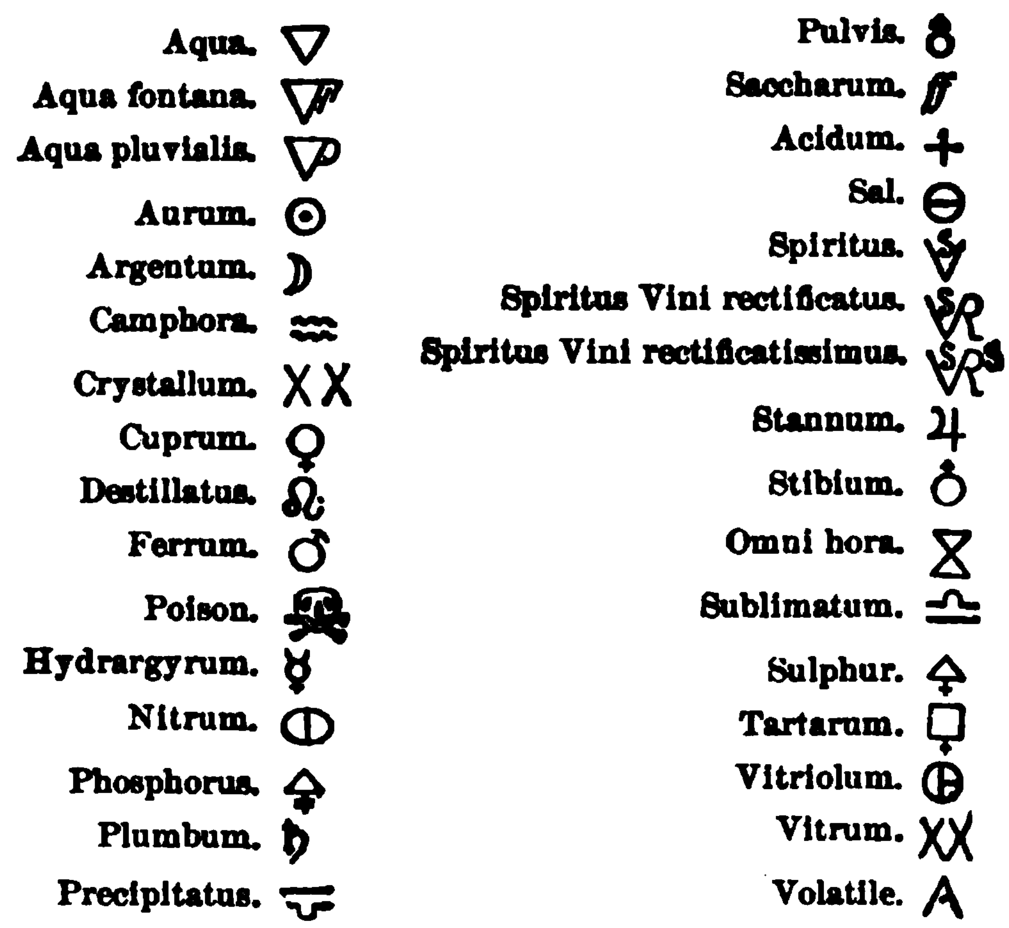
Potassii Iodidi, ...	5.0
Aquæ Camphoræ, ...	50.0
Syrupi, ...	120.0

Thus Natrium aceticum is written for Sodii Acetas; Ferrum jodatum for Ferri iodidum; Ferrum sulfuricum for Ferri Sulphas, etc.

A few physicians of the old school still employ some cabalistic

signs* (Fig. 383) derived from alchemistic times; and certain obsolete terms are occasionally employed to designate well known

FIG. 383.



remedies. The following table will explain a number of such terms.†

For Acetum plumbi	*read* Liquor Plumbi subacetatis.
" " saturninum	" " " " dilutus.
" Aqua saturni	" " " " dilutus.
" " phagedænica	" Lotio hydrargyri flava.
" " fontana	" Aqua pura.
" Aquila alba	" Hydrargyri subchloridum.
" Flores benzöes	" Acidum benzoicum.
" " naphæ	" Flores aurantii.
" " zinci	" Zinci oxidum.
" Gummi mimosæ	" Acacia.
" Lapis infernalis	" Argenti nitras.
" Magisterium bismuthi	" Bismuthi subnitras.
" Mercurius	" Hydrargyrum.
" Natrum carbonicum acidulum	" Sodii bicarbonas.
" Natro-kali tartaricum	" Potassii et sodii tartras.
" Nihilum album	" Zinci oxidum.
" Oleum anthos	" Oleum rosmarini.
" Protojoduretum hydrargyri	" Hydrargyri iodidum viride.
" Saccharum saturni	" Plumbi acetas.
" Sal amarum	" Magnesii sulphas.
" " mirabile	" Sodii sulphas.
" Tinctura thebaica	" Tinctura opii.
" Acidum phenylicum	" Acidum carbolicum.
" Aqua amygdalarum amararum	" Aqua laurocerasi.
" Calcaria usta	" Calx.
" Cortex chinæ	" Cinchona.
" Chininum	" Quinina.

* Real-Encyclopædie der Pharmacie, by Geissler and Moeller, Vol. I, p. 23, Wien.

† Selected (with alterations) from "The Art of Dispensing," *Chemist and Druggist*, London.

For Flores cinæ	*read* Santonica.
" Gutti	" Cambogia.
" Hydrargyrum amidato-bichlorat.	" Hydrargyrum ammoniatum.
" Kalium	" Potassium.
" Kali	" Potassa.
" Linimentum volatile	" Linimentum ammoniæ.
" Radix liquiritiæ	" Glycyrrhiza.
" Liquor ammonii caustici	" Liquor Ammoniæ.
" Natrium	" Sodium.
" Natrum	" Soda.
" Stibium	" Antimonium.
" Semen strychni	" Nux vomica.
" Tartarus depuratus	" Potassii bitartras.
" " natronatus	" Potassii et sodii tartras.
" " stibiatus	" Antimonii et potassii tartras.
" Tinct. opii benzoica	" Tinctura opii camphorata.
" Vinum stibiatum	" Vinum antimonii.

The quantities ordered are always understood *by weight*, unless specially specified. The metric system being employed exclusively by the Continental countries, a few typical examples are given. (See also Typical Prescriptions.)

℞.	Apomorph. mur. cryst., ...	0.04		04
	Morph. mur., ...	0.02		02
	Aquæ amygd. amar., ...	5.0	or 5	
	Elix. pectoralis, ...	20.0	20	
	Aqu. destill., ...	30.0	30	

℞.	Ammonii Chloridi, ...	10 Gm.
	Ext. Glycyrrh. Fld., ...	10 Gm.
	Aquæ Fœniculi, ...	250 Gm.

℞.	Morphinæ sulphatis, ...	0.001 Gm.
	Sacchari, ...	1.5 Gm.

French Prescription.

℞.	Kermes minéral, ...	0.10 gramme.
	Gomme arabique, ...	q. s.
	Eau destillée, ...	150 grammes.
	Teint. d'aconit, ...	6 gouttes.
	Sirop diacode, ...	30 grammes.

"TABLE OF TERMS LIKELY TO OCCUR IN FRENCH AND GERMAN PRESCRIPTIONS."*

À, *Fr.*, to, or; Trois à quatre paquets (three or four powders).

Abendessen, Abend-brod, -mahlzeit, -tisch, *Ger.*, supper. Drei von diesen Pillen vor dem Abendessen. (Three of these pills before supper.)

Acide azotique, *Fr.*, nitric acid.

Aetz - *Ger.*, caustic.

Aetzstein, *Ger.*, caustic potash.

Alcohol sulphuris, *Ger. Lat.*, carbon bisulphide.

Alcohol de soufre, *Fr.*, carbon bisulphide.

Altschädenwasser, *Ger.*, lotio flava, yellow wash.

Aqua calcaria, *G. L.*, lime water.

Aqua chlorata, *G. L.*, chlorine water.

Arsenige Säure, *Ger.*, arsenious acid.

Arsensäure, *Ger.*, arsenic acid.

Augenstein, *Ger.* lapis divinus.

Azotate, *Fr.*, nitrate.

Barbotine, *Fr.*, santonica.

Baudruche, *Fr.*, goldbeater's skin.

Bissen, *Ger.*, bolus. Sechs Bissen im Tage zu nehmen auf drei Gaben vertheilt. (Six boluses to be taken daily, divided into three doses.)

Blauholz, *Ger.*, logwood.

Bleiessig, *Ger.*, liq. plumbi subacetatis.

Bol, *Fr.*, bolus. A prendre six bols par

*Selected from "The Art of Dispensing," *Chemist and Druggist*, London.—*Ger. Lat.* or *G. L.* means "German-Latin," that is modern Latin, as employed in Germany and some other European countries.

jour en les partageant en trois doses. (Six boluses to be taken every day, dividing them into three doses.)
Bourdaine, *Fr.*, Rhamnus Frangula.
Calcaria, *G. L.*, calx or calcium.
Carboneum, *G. L.*, carbon.
Carbonicus,-a,-um, *G. L.*, carbonas, or carbonate.
Cautère potentiel, *Fr.*, caustic potash.
Chamomilla vulgaris, *G. L.*; Matricaria Chamomilla, *L.*
Chaux, *Fr.*, lime.
Chinin, *Ger.*, quinine.
Chininum, *G. L.*, quinine.
Chloratus,-a,-um, *G. L.*, chloride.
Chlorsaures, *Ger.*, chlorate.
Cinchoninum, *G. L.*, cinchonine.
Citricus,-a,-um, *G. L.*, citrate.
Coccionella, *G. L.*, cochineal.
Colla piscium, *G. L.*, ichthyocolla.
Coton cardé, *Fr.*, wadding, cotton wool.
Coucher. *Fr.*, bed-time, going to bed. À prendre deux pilules avant le coucher. (Two pills to be taken at bed-time.)
Cyanatus,-a,-um, *G. L.*, cyanidum, cyanide.
Cuillerée à café, *Fr.*, teaspoonful. Une cuillerée à café, au cas d'une attaque de toux. (A teaspoonful to be taken if the cough comes on.)
Cuillerée à soupe, *Fr.*, tablespoonful. Prenez une cuillerée à soupe toutes les deux heures. (One tablespoonful every two hours.)
Dover'sches Pulver, *Ger.*, Dover's powder.
L'effet voulu, *Fr.*, the desired effect. Une cuillerée à café toutes les demi-heures jusqu'à l'effet voulu. (A teaspoonful every half hour till it acts.)
Einspritzung, *Ger.*, injection.
Eisessig, *Ger.*, glacial acetic acid.
Emplastrum adhæsivum anglicum, *G. L.*, court plaster.
Emplastrum picatum, *G. L.*, pitch plaster.
Essen, *Ger.*, meal.
Essig, *Ger.*, vinegar.
Esslöffel, *Ger.*, tablespoon. Alle zwei Stunden einen Esslöffel-voll. (A tablespoonful every three hours.)
Ferrocyanatus,-a,-um, *G. L.*, ferrocyanide.
Flasche, *Ger.*, bottle. Schütteln Sie die Flasche. (Shake the bottle.)
Fois, *Fr.*, time. Prenez en quatre fois à une demi heure d'intervalle. (To be taken in four portions at intervals of half an hour.)
Gift, *Ger.*, poison; giftig, poisonous.
Gouttes, *Fr.*, drops. À prendre dix gouttes trois fois par jour. (Ten drops to be taken thrice daily.)
Glas, *Ger.*, glass, tumbler.
Höllenstein *Ger.*, silver nitrate, lunar caustic.
Iodure de formyle, *Fr.*, iodoform.
Kohlensäure, *Ger.*, carbonic acid.
Kümmel, *Ger.*, caraway.
À jeun, *Fr.*, fasting. Prenez deux ou trois de ces pilules à jeun. (Take two or three of these pills fasting.)
Latwerge, *Ger.*, electuary.
Lavement, *Fr.*, enema.
Limonade sèche, Fr., effervescent saline.
Liquiritia, *G. L.*, glycyrrhiza.
Mal, *Ger.*, time, portion. Auf vier Mal in halbstündigen Zwischenräumen zu nehmen. (To be taken in four portions at intervals of half an hour.)
Mittagsessen, *Ger.*, dinner (properly 'mid-day meal'). Dieses Pulver unmittelbar vor dem Mittagsessen zu nehmen. (This powder to be taken immediately before dinner.)
Natrium, *G. L.*, sodium; Natrum, *G. L.*, soda, sodium oxide.
Nüchtern, *Ger.*, sober, fasting. Vier oder sechs von diesen Pillen nüchtern zu nehmen. (Four or six of these pills to be taking fasting, or before breakfast.)
Oblate, *Ger.*, wafer. Ein Pulver vor der Mahlzeit in einer Oblate zu nehmen. (A powder to be taken in a wafer before meals.)
Ordonnance, *Fr.*, prescription.
Ouate, *Fr.*, wadding, cotton wool.
Pain azyme, *Fr.*, wafer. Un de ces paquets à prendre dans du pain azyme avant le repas. (One of these powders to be taken in a wafer before meals.)
Paquet, *Fr.*, a packet, powder. À prendre un paquet toutes les deux heures. (One powder to be taken every two hours.) On prend un de ces paquets peu de temps avant l'attaque de fièvre. (One of these powders to be taken shortly before the fever fit.)
Pasta gummosa, *G. L.*, pâte de guimauve *Fr.* Marshmallow paste.
Pastilles, *Fr.*, lozenges. À prendre de quatre à six pastilles par jour. (Four to six lozenges to be taken daily.)
Pastillen, *Ger.*, lozenges. Man nimmt von diesen Pastillen auf einmal nur eine alle zwei Stunden. (One only of these lozenges to be taken every two hours.)
Pierre à cautère, *Fr.*, caustic potash.
Pillen, *Ger.*, pills. Zwei Pillen jeden Abend vor dem Zubette-gehen. (Two pills every evening before going to bed.)
Pilules, *Fr.*, pills. Deux pilules chaque soir avant le coucher. (Two pills every evening before going to bed.)

Pincée, *Fr.*, a pinch. Infusez une pincée de ces herbes avec un demi-litre d'eau bouillante pour faire une tisane. (Infuse a pinch of these herbs in half a pint of water to make a draught.)
Potasse à la chaux, *Fr.*, caustic potash.
Potion, *Fr.*, mixture, potion.
Poudre, *Fr.*, powder. Matin et soir une poudre dix minutes avant le repas. (One powder every morning and evening, ten minutes before meals.)
Poudre alexitère *Fr.*, Dover's Powder.
Poudre anodine, *Fr.*, Dover's Powder.
Poudre diaphorétique, *Fr.*, Dover's Powder.
Poudre gazeuse, or Poudre gazifère purgative, *Fr.*, Seidlitz powder.
Poudre gazogène, *Fr.*, effervescent or gazogene powder.
Poudre gazogène neutre, *Fr.*, soda powder.
Poudre gazogène laxative, *Fr.*, Seidlitz powder.
Poudre Savory, *Fr.*, Seidlitz powder.
Poudre sudorifique, *Fr.*, Dover's Powder.
Priser par le nez, *Fr.*, to snuff. Pour priser par le nez cinq ou six fois par jour. (To be snuffed five or six times daily.)
Pulver, *Ger.*, powder. Ein Pulver jeden Morgen und Abend zehn Minuten vor dem Essen. (One powder every morning and evening, ten minutes before meals.) Man nimmt ein Pulver kurz vor Fieberanfall. (A powder to be taken shortly before the fever fit.)
Pulvis aërophorus, *G. L.*, effervescent powder, gazogene powder, soda powder.
Pulvis aërophorus laxans, *G. L.*, Seidlitz powder.
Pulvis gummosus, *G. L.*, pulvis tragacanthæ co.
Räucherkerzchen, *Ger.*, fumigating pastilles.
Räucheressig, *Ger.*, toilet or disinfecting vinegar.
Repas, *Fr.*, meals.
Rezept, *Ger.*, prescription.
Riechessig, *Ger.*, aromatic vinegar.
Saindoux, *Fr.*, lard.
Säure, *Ger.*, acid.
Schlafengehen, *Ger.*, "going-to bed," bed-time. Vor dem Schlafengehen zwei Pillen zu nehmen. (Two pills to be taken at bed-time.)
Schnupfen, *Ger.*, to snuff. Fünf bis sechs Mal im Tage zu schnupfen. (To be snuffed five or six times daily.)
Schwarzes Wasser, *Ger.*, black wash, lotio nigra.
Schwefel, *Ger.*, sulphur.
Schweflige Säure, *Ger.*, sulphurous acid.
Schwefelsäure, *Ger.*, sulphuric acid.
Sebum, *G. L.*, sevum, suet.
Sel de lait, *Fr.*, milk sugar.
Soufre végétal, *Fr.*, lycopodium.
Stibium, *G. L.*, antimonium.
Sucre de Saturne, *Fr.*, lead acetate.
Sulfuratus,-a,-um, *G. L.*, "sulphurated," sulphidum, sulphuretum, sulphide.
Sulfuricus, a,-um, *G. L.*, "sulphuric," sulphas, sulphate.
Table, *Fr.*, table. Se mettre à table. (To dine.) A prendre deux de ces pilules en se mettant à table. (Two pills to be taken before dining.)
Taffetas d'Angleterre, *Fr.*, court plaster.
Tartarus boraxatus, *G. L.*, soluble tartar, potassium boro-tartrate.
Tartarus depuratus, *G. L.*, potassium acid tartrate, cream of tartar.
Tartarus natronatus, *G. L.*, Rochelle salt, potassium and sodium tartrate.
Tartarus stibiatus, *G. L.*, tartar emetic, antimonium tartaratum.
Theelöffel, *Ger.*, a teaspoon. Ein Theelöffelvoll, a teaspoonful.
Tisane, *Fr.*, draught, medicated drink.
Tisch, *Ger.*, table. Zu Tische gehen. (To take a meal.) Man nehme zwei von diesen Pillen wenn man zu Tische geht. (Take two pills before eating.)
Trifolium fibrinum, *G. L.*, Menyanthes trifoliata, buckbean.
Tropfen, *Ger.*, drop. Drei Mal des Tages zehn Tropfen zu nehmen. (Ten drops to be taken thrice daily.)
Verordnung, *Ger.*, prescription.
Verre, *Fr.*, glass, tumbler. Un verre d'eau sucrée. (A tumbler of sugar and water.)
Wasserstoff, *Ger.*, hydrogen.
Weinsteinsäure, *Ger.*, tartaric acid.
Wirkung, *Ger.*, action, effects. Ein Theelöffelvoll alle halbe Stunden bis zur Wirkung zu nehmen. (Take a teaspoonful every half-hour until it acts.)

HOMŒOPATHIC DISPENSING.

Homœopathic medicines are prepared in the form of:—

Solutions in water, alcohol, or a mixture of these, or, very rarely, in ether, glycerin, or syrup.

Triturations with sugar of milk.

Liquid Attenuations.—Pilules and globules are merely forms of dispensing the liquid attenuations.

The mother tinctures are of the strength of 10 per cent., based on a percentage of *dry* plant. Should the fresh plant be employed, the amount of moisture is estimated and a corresponding quantity taken. The process of attenuation (dilution) begins from a point termed "zero," which is marked. This represents usually the pure medicinal substance. The strong or mother tincture is marked θ. The first decimal (1x) attenuation contains 10 per cent. of the tincture; it is made by adding 10 parts of mother tincture to 90 parts of the diluent. Or, it may be made as follows: Select a clean half-ounce bottle with a good tight-fitting cork; then put in 20 minims of the mother tincture and 180 minims of alcohol of the same strength; cork the bottle and shake. This constitutes the first decimal attenuation, and should be maıked 1x. Each subsequent attenuation is prepared in like manner from the one preceding it, and should be marked in order, 2x, 3x, etc. This constitutes the decimal scale. The centesimal attenuations are prepared in the same way, but are diluted in the proportion of 1 in 100 instead of 1 in 10, and are generally marked in figures 1, 2, 3, etc.

HOMŒOPATHIC TRITURATIONS.

Hahnemann published minute directions for making triturations, and his method is still adhered to, with the small alteration of the quantity of sugar of milk used at each stage of the process. He recommends that 1 grain of the substance be triturated with 99 grains sugar of milk for one hour. It is, however, recommended in the Homœopathic Pharmacopœia to use the proportion of 1 to 9, as it is found that a better and more perfect mixture results. The substance is to be first triturated in a clean Wedgwood mortar with an *equal* amount of sugar of milk, a horn or ivory spatula being occasionally used to scrape the mixture from the sides of the mortar. This completes the first stage of the process.

The second stage consists in adding and mixing, as before, *three* times the amount of sugar of milk used in the first stage. The third stage consists in adding and mixing, as before, *five* times the amount first used, when the trituration is regarded as completed, and can be transferred to a perfectly clean, dry bottle, carefully corked and labeled 1x. This constitutes the first deci-

mal attenuation, containing 1 part of the substance in 10. For making subsequent triturations, 1 part of the first trituration and 9 parts of sugar of milk in fine powder are mixed in two stages in a manner similar to that employed in making the first decimal trituration. It should be noted that coarse sugar of milk is used in the first and second stages of the first trituration and fine sugar of milk in all subsequent triturations.

The method of medicating pills and globules consists in putting a suitable quantity in a clean, dry bottle, and pouring over them a sufficient quantity of tincture (of the strength required) to thoroughly saturate them, shaking the bottle in a circular direction so as to insure them all being equally saturated, and then drying them by allowing the spirit to evaporate.

Tincture triturations are a form of powder now used, and for the preparation of which definite instructions are given in the Homœopathic Pharmacopœia. Briefly, they are prepared by pouring successive quantities of tincture on sugar of milk, contained in a mortar, thoroughly mixing, and allowing the mixture to dry after each addition of tincture, so that the strength of the powder ultimately obtained represents 1 minim of tincture in each grain:—

℞. Tinct. Nucis Vomicæ, 6x, ... $\frac{12}{6}$
Aquæ destill., ... f℥ vj.
M. Ft. mistura, cujus capiat cochlearia duo magna tertiis horis.
Twelve drops of the *sixth* dilution are prescribed.

℞. Nucis Vomicæ, ... $\frac{2}{3}$
Sacch. Lactis, ... q. s.
Ft. pulvis. Mitte vj.
Two grains of the *third* dilution are triturated with sufficient Sugar of Milk and made into powders.

℞. Pil. Chamomillæ, ... $\frac{3}{12}$.
Direct a pilule to be taken every three hours.
Three pilules saturated with tincture of the *twelfth* attenuation.

℞. Tinct. Belladonnæ, 3x, ... ♏xij
Aquæ destill., ... f℥ iij.
Ft. Misce. Dessertspoonful every six hours.

Tinct. Pulsatillæ Θ, ... ♏x
Aquæ dest., ... f℥ iij.
The Tincture of Belladonna should be the third attenuation.
The Tinct. of Pulsatilla should be the mother tincture (10 per cent).

℞. Trit. Mercurii sol., 6x, ... gr. ½
Mitte tales chart. xij.
This should be diluted with a little Sugar of Milk before dividing. The trituration of Mercurius Solubilis is prepared from Suboxide of Mercury (Hg_2O).

SOLUBILITIES.

In the compounding of prescriptions, an acquaintance with the general rules of solubility is of great value to the dispenser. For this purpose the general table of solubilities in water (normal temperature), as compiled by Prof. Attfield, is given:—

ACETATES.—Soluble.
ARSENATES and ARSENITES.—Insoluble, except those of alkali metals.
BROMIDES.—Soluble, except Hg(ous) and Ag.—Sb, Bi, with water form insoluble Oxysalts.
CARBONATES.—Insoluble, except those of alkali metals.
CHLORIDES.—Soluble, except Hg(ous) and Ag.—Pb sparingly.
CITRATES.—Soluble, except those of Mn, Hg(ous), Ag, Sr—Al, Ba, Bi, Cd, Cu, Pb, Zn, sparingly soluble.
CYANIDES.—Insoluble, except Hg (ic), and those of alkali metals and earths.
HYDRATES.—Insoluble, except Ba, Sr, alkali metals.—Sr, Ca, Pb, sparingly soluble.
IODIDES.—Soluble, except Sb, Bi, Au.—Pb, Hg(ic), Hg(ous), and Ag, sp'r soluble.
OXALATES.—Insoluble except alkali metals—Sb, Cr, Fe(ic), (ous), Sn(ic), sparingly soluble.
OXIDES.—Insoluble, except Ba, Sr, Ca, and alkali metals.
NITRATES.—Soluble.
SULPHATES.—Soluble, except Ba, Sr.—Ca. Sb, Hg(ous) sparingly soluble.
SULPHITES.—Soluble, except Al, Sb, Bi.—Fe(ous), Ca, Mn, Ag, Zn, sparingly soluble.
TARTRATES.—Soluble, except Sb, Ba, Bi.—Ca, Fe(ous), Pb, Mn, Hg(ic), (ous), Sr, Zn, sparingly soluble.

EXPLOSIVE MIXTURES.

Certain chemical compounds, when brought together under favorable conditions, either give rise to violent reaction, or favor the formation of new bodies which explode on the application of mechanical force. To give rise to such violent or explosive reactions all favorable conditions must be fulfilled, hence, in order to operate with such bodies with safety we must avoid these conditions as much as possible, by such precautions as previous dilution of the active agents, avoiding pressure or force, heat, etc.

The following list * is a general classification of such bodies as are liable to give rise to such difficulties.

EXPLOSIVE BODIES AND MIXTURES.†

I. *Spontaneously Inflammable Bodies.*
   Phosphorus (also subsulphide).
   Compounds of methyl and ethyl with Al, Zn, B, As, Sb, etc.

II. *Bodies Which Explode on Heating.*
   Ammonium nitrate (when suddenly or strongly heated).
   Chlorine monoxide (Cl_2O), trioxide (Cl_2O_3), tetroxide (Cl_2O_4).
   Mercurous oxalate.

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* See on this subject: "Explosive Bodies and Mixtures," by Dr. Chas. Rice, *New Remedies*, 1878, pp. 165-196. Another paper on this subject is by C. D. Lippincott, Proceed. Penn. Phar. Ass'n., 1886; see also "Art of Dispensing," London, *Chemist and Druggist*.

† Only the better known bodies are given here; for a more complete list, consult Dr. Rice's article, *New Remedies*, 1878, pp. 165-197.

Urea nitrate (suddenly heated).
Most organic *nitro-substitution* compounds, containing the group NO_2.
Picric acid explodes when quickly heated in a confined space.
Picrates when strongly heated, especially in a confined space.
Hypophosphites (also in solution) when heated too high.
Silver Chlorite ($AgClO_2$) explodes at 105° C.
Silver oxalate, citrate, fumarate, malate.
Ammonium iodate and periodate.
Chlorates explode when heated in presence of combustible bodies.
Methyl and ethyl nitrate; their heated vapor explodes.
Permanganic acid.

III. *Bodies which Explode on Percussion or when Triturated.*

Substances which contain carbon and oxygen with nitrogen in a feeble state of combination with the entire amount or a portion of the oxygen. When explosion takes place, the nitrogen is set free, and the oxygen unites with the carbon present to form carbon monoxide and dioxide. If hydrogen is present, it forms water in the shape of greatly expanded vapor. Certain nitrogen oxides when substituted in place of hydrogen, may form very explosive compounds, such as nitroglycerin or the hexanitrocellulose (gun cotton).

Chlorates should never be prescribed in powder, mixed with organic or inorganic combustible or oxidizable bodies. Some of these mixtures should never be mixed, but dispensed separately or in solution. When it is necessary that such be mixed, the greatest caution should be observed, and only small quantities should be operated on at a time, with the precaution of pulverizing each ingredient *separately* and mixing without pressure. Commercial potassium chlorate, if it contains organic impurities, will explode on trituration.

CHLORATES* WITH ORGANIC SUBSTANCES IN GENERAL, AS FOR EXAMPLE:—	Tannic and Gallic Acids, Antimony Sulphides, Amorphous Phosphorus, Charcoal, Catechu, Lycopodium, Glycerin, Sulphur, Iodine,	Oxalic Acid, Sugar, Hypophosphites, Starch, Phenol, Salicylic Acid, Morphine, Shellac.

*The preparation of colored fires is attended with much danger, as they generally contain potassium chlorate or nitrate and various easily combustible bodies. Each of the ingredients should be dried and powdered singly, then the whole mixed with a wooden spatula, with great care.

Chlorates, Bromates, and *Iodates* when rubbed or heated with iodine, sulphur, reduced iron, sulphides, etc.
Fulminates are exceedingly explosive.
Glonoin (nitroglycerin).
Nitrogen Chloride, produced by the action of chlorine on a solution of ammonium chloride.
Nitrogen Iodide, generated by bringing together iodine and ammonia. Even the vapor of ammonia on coming in contact with iodine may produce it.

Nitric Acid (fuming), with readily oxidizable substances, such as glycerin, alcohol, tinctures, volatile oils, resins, sugar, phosphides, etc. With straw or sawdust it is liable to ignite.

Permanganates with organic extracts, organic powders, organic acids, fats and oils, hypophosphites, reduced iron, sulphur, or sulphides, glycerin, alcohol, etc. These react in very dilute solutions in causing a reduction (decolorization) of the permanganate to manganate; when triturated or even mixed with many organic compounds, they give rise to violent reactions or explosions, due to the extremely loose state of combination of their oxygen.

Oxide and *nitrate of silver*, when made into pills with saccharine or other reducing agents, do not usually explode with violence, but cause the pills to swell up rapidly and to fall to pieces.

Mixtures from which a gas is evolved, should not be corked until the evolution of the gas has ceased, unless it is especially desired to confine the gas together with the liquid, in which case the necessary precautions must be taken.

The following combinations are dangerous, some of them having caused serious accidents:—

℞. Potassii Chloratis, Acidi Tannici. M.	Should *not* be triturated together, nor mixed together and dispensed in dry form. Dispense the powders separately.
℞. Potassii Chloratis, Acidi Tannici, Glycerini, Aquæ. M. Ft. Sol.	Dissolve the tannin in the glycerin, and the chlorate in the water, and then mix. Do not rub the chlorate, tannin and glycerin together.
℞. Potassii Chloratis, Sodii (or Calcii) Hypophosphitis, Aquæ. M. Ft. Sol.	The two salts must *not* be rubbed together or an explosion will result. They should be dissolved separately in water and mixed.
℞. Potassii Chloratis, . . . ℥ss–℥j Tincturæ Ferri Chloridi, ℥ss–℥ij Glycerini, ... ℥ss–℥iij.	If warmed, the mixture is liable to explode.
℞. Olei Terebinthinæ, Acidi Sulphurici or Acidi Nitrici.	These should be cautiously mixed in an open vessel, as the reaction is quite violent.
℞. Argentii Oxidi, Morphinæ Hydrochloratis, Extracti Gentianæ. M. Ft. Pill.	This pill will burst on standing, owing to the decomposition of the silver oxide by the organic extract.

℞. Potassii Chloratis, ... gr. iij Sulphuris Præcipitati, . . gr. v Zinci Valerianatis, ... gr. j Sacchari, ... gr. xx. M. Ft. pulvis. Dentur tales doses No. x.	This should not be dispensed. When carelessly mixed it is liable to explode.
℞. Potassii Permanganatis, . . ʒj Glycerini, ... f℥ss.	These, on being brought together, will cause an explosion.
℞. Acidi Chromici, ... gr. x Glycerini, ... fʒj.	This is dangerously explosive.
℞. Iodi, ... fʒss Linimenti Camphoræ Co., " Saponis, . āā f℥ij. M. Ft. linimentum.	This mixture has given rise to an explosion, owing to the formation of nitrogen iodide, from the presence of the ammonia in the Lin. Camph. Co.
℞. Acidi Nitrici, Acidi Muriatici, Tincturæ Nucis Vomicæ, āā fʒij.	This mixture is liable to explode a few hours after being mixed.
℞. Acidi Nitromuriatici, . . . f℥ss Tincturæ Cardamomi, . . f℥j.	This mixture will explode.

INCOMPATIBLES.

Incompatibility, that is, the incongruity among the constituents of a prescription, or their interference with each other, may be of three kinds, viz.: 1, chemical; 2, pharmaceutical; 3, therapeutical.

CHEMICAL INCOMPATIBILITY.*—This arises when a chemical change takes place with the formation of one or more new compounds which were not expected or intended to be produced by the prescriber. A prescription may be chemically incompatible, and yet be just what the physician desires. For instance, acids are generally said to be incompatible with alkalies, yet they are prescribed together, in many instances intentionally, so as to produce the corresponding salts. Liquor calcis is chemically incompatible with mercuric or mercurous chloride, yet the products of the reaction with either one of these chlorides are actually intended to be produced, as they are the therapeutic agents wanted. The dispenser, with a little experience, can readily distinguish a case of *intentional* from one of *unforeseen* incompatibility.

Examples.

Alkalies (caustic or carbonated) are incompatible with alkaloids in aqueous or weak alcoholic solutions; also, with acids, metallic salts, ammonia salts, etc.

Alkaloids (aqueous or weak alcoholic solutions) are precipitated from their solutions by liquids containing albumen, tannin, mercuric chloride, free iodine, Donovan's solution, Lugol's solution, double iodides, alkalies or alkali carbonates, picric acid, auric or platinic chloride, and many other compounds.

Acacia in solution forms a jelly with tincture of ferric chloride, borax, alcoholic or ethereal solutions, solution of lead subacetate, etc.

Arsenous Acid, with tannic acid, salts and oxide of iron, lime and magnesia, is rendered insoluble.

Antipyrin is incompatible with carbolic acid, nitric acid, ammonia alum, syrup of ferrous iodide. With spirit of nitrous ether or amyl nitrite, it produces a bright-green colored solution, due to the formation of iso-nitroso-antipyrin; with ferric salts, it develops an intensely red-colored solution. Like the alkaloids, it is incompatible (precipitated) with all solutions containing tannic acid (such as infusions, certain fluid extracts, tinctures, etc.), tincture of iodine, mercuric chloride, Lugol's solution, etc.

Bromides are subject to nearly the same reactions as the iodides.

Bismuth Subnitrate or *Subcarbonate* is incompatible with tannin, sulphides, mercurous and mercuric salts, etc.

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* Consult typical prescriptions given under this head.

Calomel is decomposed by alkalies, alkaline earths, their carbonates, sulphides, solution of lime, iodides, iodine, soap, acids, salts of lead, iron and copper, silver nitrate, etc.

Chlorides are incompatible with silver salts and mercurous salts, lead salts, etc.

Chloral is incompatible with alkalies ($CHCl_3$ being liberated), sulphites, ammonia water, calomel; in alcoholic solution chloral alcoholate (see Prescription No. 84) is formed; in aqueous solution it slowly undergoes decomposition, etc.

Chlorates. See page 391.

Chlorine Water is incompatible with silver, lead, and mercurous salts, organic substances, emulsions, hyposulphites, etc.

Corrosive Sublimate is incompatible with alkalies, alkali carbonates, solution of lime, the iodides or bromides, alkaloids (in aqueous solution), sulphides, reduced iron, silver nitrate, albumen, gelatin, tannic acid, etc.

Hydrogen Peroxide is incompatible with vegetable tinctures, alkali citrates and tartrates, ferrous salts. It sometimes liberates iodine from iodides. This is due to the presence of iodates, the iodine being liberated by the action of the small amount of acid present in the hydrogen peroxide.

Iodine is incompatible with ammonia or its salts, starch, metallic salts, fatty or volatile oils, emulsions, chloral, solutions containing alkaloids, sodium hyposulphite, etc.

Iron (reduced) is incompatible with vegetable extracts (containing organic acids), metallic salts, acids, mercuric chloride, potassium permanganate, etc.

Iron Salts are incompatible with alkalies and the alkali carbonates, solutions containing tannic acid, mucilages, emulsions, solutions of the iodides or bromides, etc.

Iodides. The alkali iodides, also ferrous iodide, are incompatible with the strong mineral acids, many alkaloids, metallic salts, silver nitrate, potassium chlorate, chlorine water, hydrogen peroxide (see Hydrogen Peroxide), etc.

Lime-water is incompatible with acids, ammonia compounds, salts of the metals, soluble carbonates, etc.

Lead Acetate is incompatible with iodides, bromides, chlorides and sulphates, alkalies and their carbonates, lime-water, soap, sulphides, acids, acacia, tannin, etc.

Lead Subacetate (Goulard's Extract) is incompatible with the alkali carbonates, alkalies, alkali earths, sulphuric or hydrochloric acids, sulphides, solution of acacia, solutions containing tannin, also most vegetable coloring matters, albumen, etc.

Pepsin, when combined with alkalies or alcoholic liquids, or tannates, loses its digestive activity.

Potassium Permanganate is incompatible with all organic compounds.

Quinine Sulphate gives rise to many complications. When ordered in a mixture, it should not be dissolved (by aid of an acid) unless so ordered by the physician; it is far more intensely bitter in solution than when simply suspended. Quinine and its salts can be dispensed in a suspended condition in combination with various incompatibles without inconvenience, but when it is first dissolved before combining, then many difficulties arise. Thus we may suspend the quinine in a mucilaginous mixture with such incompatibles as tannin, alkalies, salicylates, etc., without giving rise to the unsightly insoluble mass which is formed when these are added to its solution.

Strychnine when in solution combined with bromides is generally deposited, on standing, as insoluble strychnine bromide.

When any of these alkaloidal precipitants is prescribed in a solution with an alkaloid, the former should be slowly added in a well diluted condition to the latter in solution, in order to obtain the insoluble precipitate in as finely divided condition as possible, so that, when shaken, it readily remains suspended. Such incompatible combinations are admissible in mixtures containing quinine, and in many others in which the total amount of alkaloid is small. Combinations which contain larger amounts of *active* and *powerful alkaloids*, such as strychnine or morphine, as insoluble precipitates, *should under no circumstances be dispensed,* since the patient may receive the whole of the precipitated alkaloid at *one* dose.

Silver Nitrate is incompatible with chlorides, iodides, bromides, cyanides, alkali and earthy carbonates, sulphides, organic bodies, etc.

Salicylic Acid is incompatible with iron compounds, alkali iodides; salts of salicylic acid likewise with iron compounds, also with alkaloids, acids, etc.

Tartar Emetic is decomposed in solution by the addition of acids, alkalies, soap, calomel, tannin, acacia, opium, etc.

Tannin and *all solutions* containing it, are incompatible with all metallic salts, gelatin, albumen, alkali carbonates, alkaloids, etc.

PHARMACEUTICAL OR MECHANICAL INCOMPATIBILITY.*—Many substances or solutions cannot be brought to the state of a clear

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* For example:—
The addition of resinous tinctures or fluid extracts (as tinctures of guaiac, benzoin, etc.), to aqueous solutions.
The combination of emulsions with alcoholic liquids or acids, or solutions of liquorice or glycyrrhizin with acids or acid salts, tincture of iron with mucilage of acacia, infusions with ferric salts, etc.
Volatile or fixed oils with aqueous liquids.
Compound infusion of gentian with infusion of wild cherry or compound infusion of cinchona.
Alcoholic tinctures and fluid extracts, with aqueous preparations, etc., etc.

uniform mixture, the production of such being a violation of correct pharmaceutical procedure.

In many cases it is impossible to combine the ingredients of a prescription to a clear mixture, owing to the insolubility of one or more of the substances present.* While there are cases in which it is proper or even necessary to separate such insoluble matters by filtration, there are many others in which this would be inadmissible, and would defeat the intentions of the prescriber.

It is impossible to provide rules for all these cases. Each prescription has to be considered by itself. In general *a prescription may be pronounced effectively incompatible, if any of its constituents would suffer changes which weaken or destroy the intended effect, or which produce effects not intended.*

THERAPEUTIC INCOMPATIBILITY.—This occurs where there is an antagonism of physiological action, one ingredient being, as it were, an antidote to the other.

Difficulties that arise in this connection do not concern the apothecary, but lie solely within the power of the physician to correct.

GENERAL OBSERVATIONS.

It is important that the dispenser possesses an accurate knowledge of chemical reactions, solubilities and doses, in order that he may be able intelligently to compound the great variety of combinations prescribed, and discover any serious errors of judgment on the part of the prescriber. Physicians are rarely good chemists, hence the dispenser should be accordingly qualified.

Before attempting to compound a mixture, the dispenser should first satisfy himself that no error has been committed on the part of the writer, in prescribing doses of powerful remedies, that is, excessive quantities which would result in endangering the life of the patient. In such instances the physician should be consulted.

In cases of chemical incompatibility, the question that first arises is, whether this incompatibility is intentional or was unforeseen on the part of the prescriber. For example, it will be seen at once that in mixture No. 85 the incompatibility was intentional, hence it is the duty of the dispenser to compound this to the best of his ability. In the case of the prescriptions No. 37, 48, 59, etc., the dispenser will perceive that the incompatibility was unforeseen by the prescriber through his deficiency of knowledge concerning chemical reactions. Now an unforeseen incompatibility should not, under all circumstances, lead the dispenser to refuse compounding a prescription; for in such cases as prescriptions No. 63, 79, the mixture should be dispensed with certain precautions—as, to be shaken well before using. However, there are many cases in which the presence of a precipitate of a potent nature or other substances which have been set free in

* Consult typical prescriptions given under this head

the mixture (for instance, iodine, bromine, chlorine, etc.), would lead the dispenser to refuse compounding it, because it is liable to endanger the life of the patient; as examples of such, consult prescriptions Nos. 46, 64, 68, 83, etc.

The prescriber should not be troubled unless the prescription presents difficulties which the dispenser cannot overcome.

Under no circumstances should the dispenser attempt substitution.

In the compounding of various mixtures, precipitation is of very frequent occurrence. The question naturally arises, shall these precipitates be removed or not. Precipitates should not be removed, unless the solution is intended as an application to the eye or inflamed surfaces, for in such instances the particles of solid matter might prove a source of irritation. In mixtures intended for internal use, precipitation may arise from a variety of causes,* but such precipitates should not be removed, for as a rule we deprive the mixture of a portion, or in some cases, of its entire activity. For example, should we filter such mixtures as No. 55, 56, 86, etc., we would obtain a clear *inert* solution. So also if the precipitate which results from the admixture of alcoholic solutions of resinous substances with aqueous liquid, be removed, we deprive the mixture of the greater part of its activity. In other cases, the precipitate resulting is inert, yet it may, when removed, retain active matter which is retained mechanically.

Mixtures which contain precipitates of active or potent substances are a source of danger, because, unless the mixture be shaken before using, so that the precipitate will become uniformly suspended, the last doses may contain a poisonous quantity. In such instances the prescriber should be consulted. Some precipitates cannot be evenly distributed by shaking; examples are Nos. 28, 74, etc.

Insoluble powders should never be added directly to a mixture, but they should be put in a mortar and reduced to the condition of a smooth paste with a portion of the mixture (syrup or mucilage, if ordered), and then transferred to the bottle by washing the mortar with the remainder of the liquid. When such mixtures are dispensed, the proper direction regarding the necessity of shaking the bottle should be given. Soluble salts should be powdered if necessary, and dissolved in a suitable amount of the most appropriate liquid constituent of the prescription, before the remainder of the ingredients is added, the liquid which dissolves the salt the least being added last. For example, if the salt is readily soluble in aqueous and but little soluble in alcoholic liquids, it should first be dissolved in one of the aqueous constituents, and the alcoholic ones added last. And if it be more soluble in alcoholic liquids, the aqueous constituents should be added last. Potent substances, such as poisonous alkaloids or their salts, should always be in solution before being added to the mixture.

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* See Precipitation, page 156.

TYPICAL PRESCRIPTIONS

WITH EXPLANATORY NOTES.

No attempt has been made to give the names of the ingredients in strictly pharmacopœial Latin. As the prescriptions here quoted have been taken from promiscuous sources, the original phraseology or nomenclature has been preserved.

(1) General Examples.

1.

℞. Potassii Permanganatis, . . gr. xxx
Auri et Sodii Chloridi, ... gr. iss
Misce et fiant pilulæ No. xl.

Organic matter should not be employed in making these pills. Use infusorial earth, or kaolin, with petrolatum.

2.

℞. Liquoris Ammonii Acetatis, . . 60 Cc.
Tincturæ Ferri Chloridi, . . . 30 Cc.
Syrupi, ... q. s. ad 150 Cc.

If the spirit of Mindererus be alkaline, and the ferric chloride free from excess of acid, a precipitation of ferric carbonate will occur. It is necessary to make sure that the former is at least slightly acid, or to render it so by the addition of a little acetic acid.

3.

℞. Pulv. Camphoræ,
Chloral Hydratis, . . . āā 5 Gm.
Cocainæ Hydrochloratis, . . 5 Dg.
M. Apply externally.

These should be triturated together until a thick, clear fluid results.

4.

℞. Hydrargyri Chloridi Corrosivi, gr. xvj
Collodii, ... f℥ss
M. Ft. sol.

The mercuric chloride should be triturated in a small glass mortar with just sufficient alcohol for solution, then this added to the collodion.

5.

℞. Lupulini, ... 5.00
Pulveris Camphoræ, ... 1.00
Terebinthinæ Venetæ, ... 8.00
M. Fiant pilulæ No. cxxv.

The lupulin should be rubbed in a mortar until a crumbly mass results, then the powdered camphor and turpentine added, and massed with magnesia.

6.

℞. Asafœtidæ, ... ʒj
Aquæ, ... f℥viij
M. F. enema.

The asafœtida, in tears, should be reduced to a mass, and then triturated with a little water until a smooth paste results; then the remainder of the water should be added, and the mixture finally strained.

7.

℞. Olei Terebinthinæ, ... fʒiss
Syrupi Simplicis, ... f℥j
Aquæ Cinnamomi, ... f℥ij
Olei Limonis, ... ♏viij
M. Sig.—Teaspoonful as directed.

In this instance it would be advisable for the dispenser to add powd. acacia (45 grains) sufficient to emulsify the oils.

8.

℞.	Copaibæ,	10 Cc.
	Liquoris Potassæ,	3 Cc.
	Olei Gaultheriæ,	0.5 Cc.
	Glycerini,	15 Cc.
	Aquæ Cinnamomi,	60 Cc.
M.	Sig.—Teaspoonful.	

Mix the liquor potassæ with double its volume of cinnamon water in a bottle, then add gradually, with constant agitation, the copaiba and oil of wintergreen, next the glycerin and remainder of the water. The solution of potassa does not emulsify, but saponifies the copaiba.

9.

℞.	Chloroformi,	
	Acidi Nitrici,	
	Creosoti,	āā f℥v
M.	For cauterizing.	

The nitric acid should be first added to the creosote and the mixture allowed to cool before the chloroform is added, otherwise the latter would be volatilized by the heat generated by the reaction of the other two ingredients.

10.

℞.	Sodii Biboratis,	℥iv
	Chloralis,	℥ij
	Atropinæ,	gr. iv
	Spiritus Vini Rectificati,	f℥j
	Aq. Sambuci,	q. s. ad f℥xij
M.	Ft. lotio.	

This should be kept in a cool place, and well-stoppered, for chloroform will be developed by the action of the borax on the chloral.

11.

℞.		
	Potassii Chloratis,	℥ij
	Acidi Hydrochlorici,	f℥ij
	Aquæ,	f℥viij
M.	Ft. gargarisma.	

If the acid be added to the chlorate followed by the water, a yellowish colored solution will result, which contains free chlorine. If the chlorate be dissolved in the water and the acid added last, a colorless solution will result. It is best to consult the physician as to which is desired.

12.

℞.		
	Potassii Cyanidi,	gr. vj
	Morphinæ Sulphatis,	gr. ij
	Acidi Citrici,	℥iss
	Syrupi,	q. s. ad f℥viij
M.	Ft. sol. Sig.—Coch. parv. t. i d.	

Hydrocyanic acid is developed according to the equation:

$$\underset{195}{3KCN} + H_3C_6H_5O_7 = \underset{81}{3HCN} + K_3C_6H_5O_7.$$

If 195 grains of KCN are capable of yielding 81 grains of HCN, then 6 grains of KCN will yield approximately 2.5 grains of HCN, which is equivalent to about 130 minims of the official dilute hydrocyanic acid, leaving about two minims to the dose. The mixture may, however, be dispensed.

13.

℞.	Tincturæ Ferri Muriatici,	f℥ij
	Spiritus Ætheris Nitrosi,	f℥iv
	Mucilaginis Acaciæ,	f℥j
	Syrupi,	q. s. ad f℥iij

When mixed in the order written, the mixture forms a jelly-like mass. If each of the constituents be diluted with an equal quantity of the syrup, and then mixed, a clear mixture will result.

14.

℞. Extracti Buchu Fluidi,
Extracti Cubebæ Fluidi, . āā f℥j
Olei Terebinthinæ, ... fʒij
Tincturæ Hyoscyami, ... f℥ss
Mucilaginis Acaciæ, . . q.s. ad f℥iv

Mix the fluid extracts, tincture and oil of turpentine; then add this slowly to the mucilage, agitating constantly; a precipitate forms but can be readily diffused by agitation. Should we add the mucilage of acacia to the other mixed ingredients, the gum is precipitated in a lumpy condition.

15.

℞. Liquoris Strychniæ, B. P., . . ♏v
Sodii Bicarbonatis, ... gr. xv
Aquæ, ... ad f℥j

Solutions containing alkaloids are incompatible with alkalies or their carbonates, but in this case the incompatibility may be neglected. There is about $\frac{1}{20}$ of a grain of strychnine in the solution and this is precipitated by the sodium salt. But inasmuch as the alkaloid strychnine is soluble in 6700 parts of water, it will here remain in solution, as there are over 9000 parts of water to each part of liberated alkaloid.

16.

℞. Acidi Sulphurici,
Acidi Nitrici, ... āā 10.00
Olei Terebinthinæ, ... 30.00
Alcoholis, ... 50.00
M. Ft. sol.

Owing to the violent reaction which ensues on mixing these acids with oil of turpentine great caution should be observed to prevent accidents. The mixed acids should be added to the oil slowly and cautiously. The dish containing the mixture should be placed in the open air and at least at arm's length from the operator. After the mixture has cooled the alcohol may be gradually added.

17.

℞. Acid. hyd. dil., ... fʒj
Syrupi, ... f℥ij

Here is an ambiguous abbreviation; the dispenser would be at a loss as to whether hydrobromic, hydriodic, hydrochloric or hydrocyanic acid was intended. The prescriber should be consulted before dispensing.

18.

℞. Acidi Sulphurici Aromatici, . 8.00
Tincturæ Cinchonæ Compositæ, 30.00
Glycerini, ... 30.00
Aquæ Destillatæ, ... 60.00
Quininæ Sulphatis, ... 2.00
M. Ft. sol. Sig.—Cochleare parvum ter in die.

The quinine salt should be added to the compound tincture of cinchona in a graduate, and dissolved in the latter with the aid of the aromatic sulphuric acid, under stirring. Then the glycerin should be added and lastly the water. The glycerin prevents the formation of a precipitate from the tincture, when it is afterwards mixed with water.

19.

℞. Acidi Salicylici,
Sodii Bicarbonatis, ... āā ℥j
Aquæ, ... f℥vj
M. Ft. sol. Sig.—ʒj 3 t. d.

The two substances may be mixed in a large mortar, and the water gradually added, under stirring, until effervescence ceases. Or, the sodium salt may be mixed in a large capsule, on a water-bath, with the larger portion of the water, and the acid added until effervescence ceases. The solution will be of a dark color, due to the excess of alkali present at the close of the reaction :—

$$\underset{83.8}{NaHCO_3} + \underset{137.6}{HC_7H_5O_3} = \underset{159.6}{NaC_7K_5O_3} + CO_2 + H_2O$$

If the acid and the sodium salt were in molecular proportions, darkening of the solution could be prevented by dissolving the acid in boiling water (or adding it to boiling water, if there is too much to be dissolved), and then gradually adding the sodium salt to saturation.

20.

℞. Tincturæ Ferri Chloridi, . . . 10.00
Acidi Phosphorici Diluti, . . 10.00
Quininæ Sulphatis, ... 3.00
Strychninæ Sulphatis, ... 0.10
Aquæ Destillatæ, ... 100.00
Syrupi Limonis, ... 80.00
M. Sig.—Dose, a teaspoonful.

The phosphoric acid must be free from "meta" or "pyro" acid or precipitation of iron will occur. If sufficient phosphoric acid is added, the red ferric chloride changes into colorless acid ferric phosphate. The quinine salt is dissolved in the tincture, the strychnine salt in some of the water; these are added to the syrup, followed by the balance of the water and lastly the acid. After a time the phosphates of the alkaloids will precipitate. The mixture should be dispensed with a "shake label."

21.

℞. Copaibæ, ... 20.00
Tincturæ Lavandulæ Compositæ,
Spiritus Ætheris Nitrosi, . . āā 10.00
Olei Gaultheriæ, ... 0.50
Mucilaginis Acaciæ, ... 30.00
Aquæ Destillatæ, . q. s. ut ft. 250.00
M. sec. art. Sig.—Coch. mag. t. i. d.

To the mucilage contained in a bottle add the copaiba and oil in small portions at a time, shaking well after each addition. Then add the greater part of the water, next the tincture and spirit, all in portions, and lastly the remainder of the water. The balsam and oil are made into a sort of emulsion with the mucilage, and the alcoholic liquids are added last.

22.

℞. Olei Jecoris Aselli, ... f℥ viij
Olei Amygdalæ Amaræ,
Olei Gaultheriæ, ... āā ♏x
Pepsini pulv., ... ʒj
Pancreatini. . . . . ʒj
Pulveris Acaciæ, ... ℥j
Glycerini. . . . . f℥j
Syr. Hypophosphitum, ... f℥j
Acidi Phosphorici Diluti, . . . f℥ss
Aquæ Destillatæ. . q.s. ut ft. f℥ xvj
M. Ft. [illegible] art.
Sig.—Coch. mag. t. i. d.

Triturate one-half of the cod-liver oil and the essential oils with the pepsin, pancreatin and acacia; add at once one-half of the water, and triturate rapidly until an emulsion results. To this add gradually the remainder of the cod-liver oil, using a little water to prevent the emulsion from separating ("cracking"). Next incorporate the syrup and the remainder of the water, leaving room for the acid, which is to be added last.

(2) Pharmaceutical Incompatibility.

23.

℞. Tincturæ Ferri Muriatici, . . . fʒj
Decocti Uvæ Ursi, ... f℥ vj
M. Signa.—Coch. mag. t. i. d.

The tannin of the Uva Ursi forms an inky mixture (tannate of iron) with the ferric chloride.

24.

℞. Extracti Buchu Fluidi,
Extracti Cubebæ Fluidi, . āā f℥ iss
Aquæ Cinnamomi, ... f℥ iij
M. Sig.—To be well shaken.

This forms a very unsightly mixture, owing to the separation of the resinous and oily matter when the fluid extracts are added to the cinnamon water.

25.

℞.	Tincturæ Ferri Chloridi, . . .	f℥ iij
	Tincturæ Guaiaci Ammoniatæ, ...	f℥ j
	Tincturæ Aloes, ...	f℥ ss
	Syrupi, ... q. s. ad.	f℥ iv

This forms a black mixture, the tincture of guaiac being pharmaceutically incompatible with the ferric chloride. Also both resinous tinctures precipitate on coming in contact with an aqueous solution, in this case the syrup.

26.

℞.	Chloral Hydratis, ...	gr. xl
	Camphoræ, ...	gr. x
	Syrupi Zingiberis, ...	f℥ ij
	Aquæ, ... q. s. ad.	f℥ ij

The chloral should be dissolved in the syrup, and the camphor, reduced to fine powder, be gradually mixed by trituration with the syrup, so that it may remain in suspension. The mixture should be directed to be well shaken before being used.

27.

℞.	Ferri et Quininæ Citratis, . .	10.00
	Acidi Phosphorici Diluti, . .	10.00
	Tincturæ Cardamomi Compositæ, ...	30.00
	Syrupi Limonis, ...	20.00
	Aquæ, ...	100.00

The scale salt is dissolved in the water, followed by the syrup, tincture and acid in order. The mixture will not be clear because of the separation of the resinous matter of the cardamom. The quinine phosphate which is formed, owing to its comparative insolubility, will generally precipitate.

28.

℞.	Tincturæ Guaiaci Ammoniatæ,		
	Mucilaginis Acaciæ, . . .	āā	f℥ j
	Potassii Iodidi, ...		℈ ij
	Tincturæ Hyoscyami, ...		f℥ ss
	Aquæ Cinnamomi, . q. s. ad. .		f℥ iij

This forms an unsightly mixture, owing to the separation of the resinous matter of the tincture of guaiac, which adheres to the sides of the bottle.

29.

℞.	Copaibæ,		
	Spiritus Ætheris Nitrosi. .	āā	f℥ iss
	Extracti Cubebæ Fluidi,		
	Tincturæ Cinnamomi, . .	āā	f℥ iv
	Mucilaginis Acaciæ, ...		f℥ j
M.			

If the copaiba is emulsified by the mucilage, the addition of the alcoholic liquids will cause the gum to separate in a solid mass. As it stands it cannot be dispensed.

30.

℞.	Extracti Buchu Fluidi,		
	Extracti Cubebæ Fluidi,		
	Mucilaginis Acaciæ, ...	āā	f℥ j
	Olei Terebinthinæ, ...		fℨ j
	Tincturæ Hyoscyami, ...		f℥ ss
M.			

The mucilage of acacia is intended to emulsify the turpentine. This emulsion is, however, destroyed by the addition of the fluid extracts and tincture, the alcohol of which coagulates the acacia.

31.

℞.	Potassii Bromidi, ...	ℨ vj
	Aquæ Camphoræ, ...	f℥ vj
M.	Ft. solutio.	

The addition of soluble salts to camphor water causes the separation of the camphor, which floats on the surface of the mixture. The mixture should be well agitated before being taken. The addition of soluble salts to any of the medicated waters causes a separation of most of the volatile constituents.

32.

℞. Extracti Cannabis Indicæ
Fluidi, ... f℥j
Copaibæ, ... f℥iv
Tincturæ Guaiaci, ... f℥ij
Spiritus Terebinthinæ, ... f℥ij
Tincturæ Camphoræ, ... f℥ss
Syrupi Zingiberis, . . . q.s. ad. f℥iv
M. Ft. mistura.

Upon mixing the first five ingredients a clear or nearly clear solution will result. Upon adding this to the syrup, the resinous matters, camphor, copaiba and oil will separate, rendering the mixture unsightly.

33.

℞. Acidi Carbolici, ... 10.00
Collodii, ... 90.00
M. Ft. sol.

On mixing these, a jelly will be produced.

(3) Chemical Incompatibility.

34.

℞. Argenti Nitratis, ... gr. v
Tincturæ Opii, ... f℥iss
Aquæ Cinnamomi, . . q.s. ad f℥ij

Silver nitrate, when brought into contact with organic substances, suffers reduction to metallic silver.

35.

℞. Argenti Nitratis, ... 1.50
Sodii Chloridi, ...60
Aqua, ... 200.00
Sig.—Use as a wash.

There is sufficient sodium chloride present to decompose the entire amount of argentic nitrate. The precipitate that forms being argentic chloride. The solution is practically inert. The reaction is as follows; $AgNO_3 + NaCl = NaNO_3 + AgCl$.

36.

℞. Liquoris Plumbi Subacetatis, . . f℥ss
Mucilaginis Acaciæ, ... f℥j
Aquæ Destillatæ, . . q. s. ad. f℥iv
M. Ft. lotio.

The Goulard's Extract produces a heavy white precipitate with the mucilage of acacia. The mixture is incompatible and should not be dispensed.

37.

℞. Strychnii Nitratis, ... gr. ij
Sol. Fowleri, ... f℥j
M. Sig.—Gtt. v, t. i. d.

This would prove to be a dangerous mixture if dispensed as written, for the alkalinity of the Fowler's solution will cause the precipitation of the strychnine. The addition of a few drops of dilute nitric acid sufficient to retain the strychnine in solution would remove the difficulty.

38.

℞. Lithii Salicylatis, ... ℥ij
Ferri et Ammonii Citratis, . . . ℥iv
Syrupi Limonis,
Aquæ, ... āā f℥iv

On bringing together the solutions of the first two ingredients, a reddish-brown precipitate of ferric salicylate will form. The prescriber should be notified, if possible. If this is impossible, directions to shake the bottle should be added.

39.

℞. Cocainæ Hydrochloratis, . . . 2 Gm.
Sodii Biboratis, ... 5 Dg.
Aquæ Destillatæ, ... 100 Cc.
M. Ft. sol. Sig.—Apply, as directed, to the eye.

The cocaine is precipitated by the borax. Boric acid should have been used.

40.

℞.	Hydrargyri Chloridi Corrosivi, .	gr. iij
	Tincturæ Cinchonæ Compositæ,	f℥ vij
	Spiritus Ammoniæ Aromatici, .	f℥ j
M.	Ft. sol.	

This mixture should not be dispensed, because the mercuric chloride will be entirely decomposed by the alkali hydrate and carbonate present in the aromatic spirit of ammonia, and the whole of the mercury be precipitated; part of which as ammoniated mercury.

41.

℞.	Aluminis, ...	gr. xxx
	Ammonii Carbonatis, ...	gr. lx
	Tincturæ Belladonnæ, ...	f℥ ij
	Glycerini, ...	f℥ iij
	Infusum Senegæ. . . q.s. ad	f℥ viij

On adding the solution of the ammonium salt to that of the alum, a precipitate of aluminum hydrate will fall, carrying with it the coloring matter and activity of the tincture of belladonna and infusion of senega. It is not advisable to dispense this.

42.

℞.	Potassii Permanganatis, ...	ʒ j
	Glycerini, ...	fʒ j
	Aquæ, ...	f℥ ij

The glycerin (being organic) causes decomposition of the permanganate; instead of a bright, red-colored solution, a colorless liquid with a dark precipitate (of manganic oxide) will result.

43.

℞.	Quininæ Sulphatis, ...	1.30
	Sodii Salicylatis, ...	15.50
	Acidi Hydrobromici Diluti, .	30 Cc.
	Aquæ, ... q. s. ad	250 Cc.

No matter how compounded, this mixture will contain a heavy precipitate of salicylic acid caused by the decomposition of the sodium salicylate by the hydrobromic acid.

44.

℞.	Liquoris Hydrargyri Perchloridi,	♏x
	Potassii Iodidi, ...	gr. x
	Decocti Cinchonæ, . . . q. s. ad	f℥ j

Liquor Hydrargyri Perchloridi is official in the British Pharmacopœia. It contains 10 grs. each of $HgCl_2$ and NH_4Cl in 1 pint (Brit.) of water. The addition of potassium iodide to this will produce the reagent known as Mayer's, which causes a precipitate with the alkaloids of the decoction of Cinchona to form. To render this as diffusible as possible it is best to add the solution of the mercury salt to a portion of the decoction, and to dissolve the potassium iodide in another portion, then to mix the two gradually.

45.

℞.	Ferri et Quininæ Citratis, . . .	2.00
	Potassii Iodidi, ...	5.00
	Syrupi,	
	Aquæ Destillatæ, ... āā	30.00

Potassium iodide and the scale salt are incompatible, hydriodate of quinine being precipitated; should the solution become warm, the precipitate would form a sticky mass.

46.

℞.	Liquoris Ferri Perchloridi, . . .	♏xx
	Potassii Bromidi, ...	gr. xxx
	Aquæ, ...	f℥ ij

This mixture would not be safe to dispense if the ferric chloride contains an excess of acid, because of the liberation of bromine; however, if the liquor be nearly neutral no difficulty will occur.

47.

℞. Strychninæ Sulphatis, ... 0.065
Potassii Bromidi, ... 25.000
Aquæ, ... q. s. ad 250 Cc.
M. Ft. sol.

The strychnia sulphate is dissolved in a portion of the water, and the bromide in the remainder; a clear solution will result. On standing over two days, crystals of strychniæ hydrobromate will gradually separate. If one fluid ounce of alcohol be used in place of water, no precipitate will appear.

48.

℞. Tinct. Guaiaci Ammoniatæ, . . ʒ ij
Mucilag. Acaciæ, ... ʒ ij
Quin. Sulph., ... gr. viij
Acid. Sulph. Dil., ... ʒ iv
Potass. Bicarb., ... ʒ j
Aquæ, ... q. s. ad ℥ iv

The potassium bicarbonate being in excess will precipitate the quinine, and the resin of the ammoniated tincture of guaiac will be thrown out by the water. The mixture is hopelessly incompatible.

49.

℞. Acidi Carbolici, ... 5.00
Sodii Bicarbonatis, ... 20.00
Sodii Biboratis, ... 30.00
Glycerini, ... 360.00

On mixing these, active effervescence follows. Glycerin reacting with borax (sodium biborate) combines with part of the boric acid to form glyceryl metaborate ($C_3H_5BO_3$) and sodium metaborate ($NaBO_2$). The glyceryl metaborate, in presence of water, resolves itself into glycerin and boric acid; the latter reacts with the sodium bicarbonate liberating carbon dioxide.

50.

℞. Quininæ Bisulphatis, ... ʒ ss
Extracti Eucalypti Fluidi, . . . f℥ j
Aquæ, ... f℥ ij
M. Ft. sol.
Sig.—Cochleare parvum omni hora sumatur.

The tannic acid of the fluid extract unites with the quinine to form the insoluble quinine tannate, which separates in the form of an insoluble precipitate.

51.

℞. Potassii Iodidi, ... ℈ j
Syrupi Ferri Iodidi, ... fʒ iv
Aquæ, ... q. s. ad f℥ j

Syrup of Ferrous Iodide generally gives with potassium iodide a precipitate of ferr*ous*, quickly changing to ferr*ic* carbonate or hydrate, because the KI is usually slightly alkaline. The addition of a little citric acid to the solution of the iodide will keep the mixture clear.

52.

℞. Plumbi Acetatis, ... ℈ j
Tincturæ Opii, ... fʒ ij
Syrupi, ... fʒ vj
Aquæ, ... q. s. ad f℥ viij
M. Ft. lotio.

The lead salt should be dissolved in an excess of the water and added to the diluted tincture. The precipitate formed should not be filtered off.

53.

℞. Argenti Oxidi, ... gr. vj
Creosoti, ... gtt. vj
Pulveris Radicis Glycyrrhizæ, q. s.
M. Fiant pil. No. vj.

Silver oxide parts with its oxygen with great facility and often with explosive force when combined with organic substances.

54.

℞. Potassii Iodidi, ... 12.0
Tr. Digitalis, ... 8.0
Extracti Erythroxyli Fluidi, . . 30.0
Sp. Ætheris Nitrosi, ... 30.0
Glycerini, ... 30.0
Aquæ, ... q. s. ad 125.0

When the ingredients are mixed in the order given and shaken, effervescence will occur, with evolution of nitrous fumes. Preparations containing tannic acid react with nitrous ether, resulting in its decomposition. The spirit of nitrous ether should be added last and in portions, and the mixture should be allowed to stand uncorked for at least five hours for the escape of nitrous fumes.

55.

℞. Liq. Plumbi Subac. Dil., . . . f℥iv
Extracti Opii Aquosi, ... gr. xx
M. Ft. lotio.

The extract of opium, if not already in powder, should be reduced to a fine powder and triturated with the "lead water" gradually added. The turbid mixture should *not* be filtered.

56.

℞. Hydrargyri Chloridi Corrosivi, gr. j
Liquoris Calcis, ... f℥viij
M. Ft. lotio.

This forms the well-known "Yellow Wash." The yellow precipitate formed consists of mercuric oxide. This should not be filtered off.

57.

℞. Potassii Iodidi, ... ʒiss
Tincturæ Ferri Perchloridi, . . f℥ss
Aquæ, ... q. s. ad f℥iv
M. Signa.—Cochleare parvum ter in die.

This mixture should not be dispensed, because of the presence of free iodine, liberated by the action of ferric chloride :—
$Fe_2Cl_6 + 2KI = I_2 + 2FeCl_2 + 2KCl$.

58.

℞. Caffeinæ Citratæ,
Ammonii Carbonatis, ... aa ℈ij
Elixir Guaranæ, ... f℥j
M. Signa.—Cochleare parvum p. r. n.

The alkali carbonate precipitates the caffeine from both of the other ingredients. The patient should receive caution to shake the bottle before using.

59.

℞. Potassii Bromidi, ... gr. x
Calomelanos, ... gr. iij
M. Ft. pulv.; mitte tales vj.

On pulverizing these two together, the mixture will acquire a dark color, due to the separation of metallic mercury, mercuric bromide being formed at the same time. The powders should not be dispensed.

60.

℞. Bismuthi Subnitratis, ... ʒj
Sodii Bicarbonatis, ... gr. xxx
M. Fiant pil. No. xx.

These pills, after being made, swell considerably and disintegrate. This is due to the evolution of carbonic acid gas, caused by the reaction between the subnitrate and the bicarbonate.

61.

℞. Potassii Bitartratis, ... ℥j
" Iodidi, ... ʒj
Spiritus Ætheris Nitrosi, . . . fʒiv
Syrupi Aurantii, ... f℥iv
Aquæ, ... q. s. ad f℥x

The following reaction takes place, resulting in the decomposition of the nitrous ether and the liberating of free iodine from the iodide: $KHC_4H_4O_6 + C_2H_5NO_2 + KI = K_2C_4H_4O_6 + C_2H_5 \cdot OH + NO + I$. The mixture should not be dispensed.

62.

℞. Morphinæ Acetatis, ... 0.05
Potassii Iodidi, ... 2.00
Ferri Sulphatis, ... 1.00
Aquæ, ... 50.00
M. Ft. sol.
Sig.—Cochleare parvum omnibus noctibus.

The addition of potassium iodide to such metallic salts as iron or copper sulphate gives rise to the precipitation of the iodide of the metal as well as the liberation of free iodine. The mixture is incompatible and should not be dispensed.

63.

℞. Calcii Sulphidi, ... gr. xv
Liquoris Hydrargyri Perchloridi, ʒ vj
Potassii Iodidi, ... gr. xj
Potassii Bicarbonatis, ... ʒ iij
Aquæ Chloroformi, . . q. s. ad ℥ viij

If the calcium sulphide be added to the solution of the mercuric chloride, the latter will be decomposed with formation of mercuric sulphide. If the potassium bicarbonate be added to the mercuric chloride, mercuric carbonate or oxychloride will be thrown down. However, as the amount of mercury salt present in the mixture is comparatively small, the mixture might be dispensed, with directions to shake the bottle.

64.

℞. Potassii Chloratis, ... ʒ ij
Syrupi Ferri Iodidi, ... f℥ ij
Vini Antimonii, ... fʒ ss
Spiritus Chloroformi, ... fʒ ij
Aquæ, ... q. s. ad. f℥ viij

The addition of the potassium chlorate to the solution containing the ferrous iodide causes a liberation of free iodine. Under the circumstances the mixture would be dangerous to dispense.

65.

℞. Liquoris Strychninæ Hydrochloratis, ... ♏c
Liquoris Arsenicalis, ... ♏ lxx
" Potassæ, ... fʒ ij
Spiritus Vini Rectificati, . . . f℥ iij

The strychnine is precipitated by the alkali, but redissolved by the alcohol. In compounding, add the liquor potassæ last.

66.

℞. Tincturæ Myrrhæ, ... fʒ ij
Morphinæ Acetatis, ... gr. j
Acidi Tannici, ... ʒ ss
Syrupi Zingiberis, ... f℥ j
M. Ft. sol.

The tannin unites with the morphine, forming an insoluble precipitate. The tinct. of myrrh precipitates its resin when added to the syrup. A hopeless case of chemical and pharmaceutical incompatibility.

67.

℞. Iode métallique, ... 10 Gm.
Alcool, ... 30 Gm.
Essence de térébenthine, . . 200 Gm.
(To be used as spray).

There is an insufficient amount of alcohol for dissolving all of the iodine; hence to the powdered iodine mixed with the alcohol, the oil of turpentine is slowly added. Ignition would result if the iodine and turpentine were brought together directly.

68

℞. Strychninæ Hydrochloratis, . . gr. j
Tincturæ Cinchonæ, ... f℥j
Liquoris Ferri Dialysati, . . . fℨiv
Liquoris Potassii Arsenitis, . . fℨij
Syrupi, ... f℥iij
Aquæ, ... q. s. ad. f℥iv
M. Ft. solutio.
Signa.—Capiat cochleare parvum post prandium.

The dialyzed iron forms an insoluble inert compound with the Fowler's Solution. There is also danger of the strychnine being thrown out of solution by the alkali of the Fowler's Solution, which would render the mixture dangerous to dispense, as the whole of the strychnine might possibly be given with the last dose.

69

℞. Liquoris Ferri Dialysati, . . . 25.00
Liquoris Potassii Arsenitis, . . . 4.00

Hydrated oxide of iron will separate, produced by the action of the alkali carbonate of the Fowler's Solution. This ferric hydrate combines to the inert insoluble *ferrous arsenate*, with the arsenous acid of the Fowler's Solution. Dialyzed iron is employed as an antidote for arsenical poisoning.

70.

℞. Potassii Cyanidi,
Chloralis, ... āā 10.0
Unguenti, ... 30.0

On bringing the chloral and potassium cyanide in contact, decomposition takes place at once, with the disengagement of hydrocyanic acid. In this case immediate reaction may be prevented by triturating the substances separately with a portion of the ointment. However, the ointment will turn brown in a short time, with disengagement of hydrocyanic acid.

71.

℞. Zinci Phosphidi
Potassii Permanganatis, . . āā gr. x
Extracti Taraxaci, . . . q. s.
M. Ft. pil. cxx.

The phosphide and permanganate should not be triturated together. Zinc phosphide, when combined with many organic extracts, gives off phosphoretted hydrogen (PH_3), while potassium permanganate is immediately decomposed under the same circumstances. This should not be dispensed.

72.

℞. Liquoris Arsenicalis (Fowl.), . . fℨj
Hydrargyri Perchloridi, ... gr. j
Aquæ, ... q. s. ad f℥iv
M. Ft. mist.
Sig.—fℨij t. i. d.

The alkali carbonate of the Fowler's solution decomposes the mercuric chloride which has been dissolved in the water, with formation of mercuric carbonate or oxychloride. The prescriber should have chosen Liquor Acidi Arsenosi. If circumstances are such that the mixture must be dispensed at once without consulting the prescriber, the patient should be instructed to shake the bottle, in order to avoid the risk of taking the entire precipitate with the last dose.

73.

℞. Syrupi Ferri Iodidi,
Liquoris Potassii Arsenitis, āā fℨij
Syrupi Tolutanæ, . . q. s. ad f℥iij

The alkali carbonate of the Fowler's solution precipitates a portion of the iron first as ferrous carbonate, which soon loses its CO_2, and eventually changes to ferric hydroxide. The iodine liberated unites with the potassium. The intentions of the physician are defeated by this incompatibility, hence he should be consulted. Otherwise nothing

would be left for the dispenser to do but to compound the mixture by diluting each of the active ingredients with half of the Syrup of Tolu and mixing gradually. The proper precautions in regard to shaking before using should be observed.

74.

℞. Quininæ Sulphatis, ... 2.0 Gm.
Tincturæ Cantharidis, . . . 3.5 Cc.
Spiritus Rosmarini, . . . 15.0 Cc.
Infusi Salviæ, ... 120.0 Cc.
M. Ft. lotio. Sig.—Apply to scalp as directed.

The tannic acid in the infusion forms an insoluble mass with the quinine. The mixture is unmanageable.

75.

℞. Extracti Buchu Fluidi, ... f℥j
Potassii Citratis, ... ʒiij
Spiritus Ætheris Nitrosi, . . . f℥ss
Syrupi Limonis, . . q. s. ad f℥viij

Spirit of nitrous ether effervesces quite violently when added to fluid extract of buchu or uva ursi, or any preparation containing tannin. The potassium citrate, when alkaline, causes the decomposition of the nitrous ether.

76.

℞. Hydrargyri Iodidi Rubri, . . . 0.20
Potassii Iodidi, ... 12.00
Ext. Cinchonæ Fluidi, ... 20.00
Syrupi, ... 150.00
M. Ft. sol., cujus æger cap. coch. parvum ter in die in cyatho vinario aq. frig. post jentac., prand. et cenam.

The mercuric iodide and potassium iodide are dissolved in the smallest possible amount of water, replacing an equal bulk of syrup. Next the fluid extract is gradually added. The whole of the cinchona alkaloids contained in this will be precipitated by the potassio-mercuric iodide. A "shake" label should be attached.

77.

℞. Plumbi Acetatis, ... gr. xl
Bismuthi Subnitratis, ... ʒss
Acidi Sulphurici Aromatici, . . fʒss
Quininæ Sulphatis, ... gr. xx
Aquæ Anisi, ... q. s. ad f℥iv
M. Ft. sol.

Upon addition of the aromatic sulphuric acid to the solution of the lead salt, lead sulphate will be precipitated. As this would be likely to be all taken with the last dose, and as it is, moreover, liable to remain for a long time in the digestive organs, and apt to cause lead-poisoning, the mixture should not be dispensed without the prescriber being consulted. If this be impossible, the lead sulphate should be removed by filtration.

78.

℞. Aluminis, ... ʒj
Plumbi Acetat., ... ʒv
Aquæ Destillatæ, ... f℥xij
M. Ft. lotio.

Each of the salts is dissolved in a separate portion of water. On mixing these solutions a heavy precipitate of lead sulphate falls, resulting from the reaction between the aluminum and potassium sulphate and the lead acetate. Unless the prescriber directs otherwise, the lead sulphate should not be removed by filtration, but directions to shake the mixture before use should be attached.

79.

℞. Acidi Tannici, ... gr. x
Quininæ Sulphatis, ... gr. iij
Acidi Sulphurici Diluti, ... ♏iij
Aquæ, ... q. s. ad f℥j

The quinine salt should be dissolved in one-half of the water by aid of the dilute acid; to this add slowly the solution of the tannic acid in the remainder of the water; a light flocculent precipitate of quinine tannate will result. Dispense with a shake label.

80.

℞. Olei Morrhuæ, ... f℥iv
Aquæ Calcis, ... f℥iv
Solve et. adde :—
Syrupi Ferri Iodidi, ... fℨiv
Olei Cinnamomi, ... fℨss
Syrupi, ... f℥xij

The lime-water serves the purpose of emulsionizing, or, rather, partially saponifying, the cod-liver oil. But on bringing this mixture in contact with the ferrous iodide, ferrous hydrate will be precipitated, while the iodine will combine with the calcium.

81.

℞. Liquoris Arseni et Hydrargyri Iodidi, ... 10 Cc.
Potassii Iodidi, ... 5 Gm.
Quininæ Sulphatis, ... 2 Gm.
Acidi Sulphurici Diluti, . . . q. s.
Aquæ, ... q. s. ad 300 Cc.

The Donovan's Solution forms with the quinine an insoluble compound which precipitates. The quinine solution should be added last and in small portions to the mixture in order to obtain the precipitate in as finely subdivided a condition as possible.

82.

℞. Sodii Salicylatis, ... 8 Gm.
Quininæ Sulphatis, ... 5 Dg.
Liquoris Ammonii Acetatis, . 10 Cc.
Syrupi Zingiberis, . . q. s. ad 60 Cc.
M. Sig.—Teaspoonful in water.

The two salts are dissolved in the solution of ammonium acetate, which, for this purpose, must be neutral. The solution is then mixed with the syrup. If the spirit of Mindererus were acid, some of the salicylic acid would be thrown out of solution. On diluting the finished, clear mixture with water, insoluble quinine salicylate precipitates.

83.

℞. Liquoris Acidi Arsenosi, . . . fℨj
Hydrargyri Bichloridi, ... gr. j
Strychninæ Sulphatis, ... gr. j
Spiritus Vini Rectificati, ... fℨj
Aquæ, ... f℥j

When strychnine and mercuric chloride are brought together in solution in the presence of hydrochloric acid, a dense precipitate of strychnine chloro-mercurate is thrown down. This is insoluble in water, but soluble in alcohol. In this mixture there is not sufficient alcohol to effect solution. *In dispensing this, or, in fact, any mixture which contains a potent substance in the form of an insoluble precipitate, a great risk will be incurred by the dispenser, for any carelessness on the part of the patient, in omitting to shake the bottle, may be attended with serious results.*

84.

℞. Potassii Bromidi,
Chloralis Hydrat., ... āā 10 Gm.
Tincturæ Opii Camphoratæ,
Syrupi Zingiberis, ... āā 50 Cc.

On standing, chloral-alcoholate will separate as oily drops. Certain salts, as KBr, NaBr, NaCl, $MgSO_4$, etc., cause the formation of chloral alcoholate (CCl_3COH,C_2H_6O) in hydro-

alcoholic solutions with chloral. While this chloral alcoholate acts as an hypnotic, it is harsh in its action, leaving unpleasant secondary effects. Alcoholic preparations should not be prescribed with chloral, especially not in connection with the bromides of sodium and potassium, because, if the solutions used are at all concentrated, the chloral will separate as alcoholate, float on the surface, and a great risk will be incurred of giving a large overdose if the patient is not very careful to shake the bottle before taking a dose.

85.

℞. Zinci Sulphatis,
Plumbi Acetatis, ... āā gr. x
Vini Opii,
Tincturæ Catechu . . . . . āā f℥ij
Aquæ, ... q. s. ad f℥iv
M. Ft. sol.

This forms an unsightly and incompatible mixture, yet should be dispensed *unfiltered*. The zinc sulphate and lead acetate* react, producing the insoluble lead sulphate. Lead acetate is incompatible with the wine of opium and tincture of catechu. The zinc sulphate and lead acetate should each be dissolved in two ounces of water and mixed, and the wine of opium should be diluted with an ounce of water and added, followed by the tincture of catechu, likewise diluted. This yields a brownish colored liquid, holding a fine precipitate in suspension.

86.

℞. Hydrargyri Chloridi Corrosivi, gr. iij
Aquæ Destillatæ, ... f℥iss
M. ft. solutio et adde :—
Albuminis Ovi, ... f℥iss
Aquæ Destillatæ, . . . q. s. ad f℥v
Misce, cola, et adde :—
Aquæ destillatæ, . . . q. s. ad f℥x

On adding the solution of the mercuric chloride to the solution of the egg albumen, an insoluble compound forms, which, when the mixture is strained, removes the entire amount of mercuric chloride, resulting in an inert solution.

87.

℞. Hydrargyri Chloridi Corrosivi,
Ammonii Chloridi, ... āā gr. iij
Aquæ Destillatæ, ... f℥iss
M. ft solutio et adde :—
Albuminis Ovi, ... f℥iss
Aquæ Destillatæ, . . . q. s. ad f℥v
Misce, cola, et adde :—
Aquæ Destillatæ . . . q. s. ad f℥x

The ammonium chloride assists the solution of the mercuric chloride in the water. It also prevents the formation of the insoluble compound of the mercuric salt with the albumen.

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* *Lead Acetate* is incompatible with such preparations as contain organic acids, as it forms insoluble compounds with these. In the above instance it unites, forming an insoluble compound, with the meconic acid of the opium and the catechuic acid of the catechu.

Lead Subacetate, being of an alkaline reaction, precipitates alkaloids, organic acids, solutions of gummy and coloring matters, tannins, albumen, etc.

PART IV.

VOLUMETRIC QUANTITATIVE ANALYSIS.

CHAPTER XXXVII.

VOLUMETRIC ANALYSIS is the method by which we determine the *quantity* of certain substances by means of the *volume* of selected reagents which are required to perform a given reaction.

The process of adding the liquid reagent from graduated measures is called *Titration*.

The strength of a volumetric solution as compared with that of another, or, in other words, its ratio to the latter, is called its *Titer*.

A VOLUMETRIC OR STANDARD SOLUTION is a solution of definite strength, which is made by dissolving a given *weight* (in grammes) of a reagent, in a definite *volume* (in cubic centimeters) of water. These solutions are usually made by dissolving the molecular weight of a reagent in grammes or a fraction thereof in 1000 cubic centimeters (one liter) of water. The following abbreviations are in use:

N or $\frac{N}{1}$ (*normal*). "Volumetric solutions are designated as normal $(\frac{N}{1})$ when they contain in 1 liter the *molecular weight* of the active reagent, expressed in grammes, and reduced to the valency corresponding to one atom of replaceable hydrogen or its equivalent.

"Thus, hydrochloric acid, $HCl = 36.37$, having but one H atom replaceable by a basic element, has 36.37 Gm. of HCl in 1000 Cc. of the normal volumetric solution; while sulphuric acid, $H_2SO_4 = 97.82$, having two replaceable H atoms, contains only one-half this number, or 48.91 grammes of H_2SO_4 in 1000 Cc. of its normal solution. Potassium hydrate, $KOH = 55.99$, has but one K to replace one H in acids, hence its normal solution contains 55.95 grammes of KOH in one liter." (U. S. P.)

$\frac{N}{10}$ (*decinormal*) = Solutions which contain in one liter *one-tenth* of the quantity of the active reagent in the normal solution.

$\frac{N}{100}$ (*centinormal*) = Solutions which contain in one liter *one hundredth* of the quantity of the active reagent in the normal solution.

$\frac{2}{N}$ (*double normal*) = Solutions which contain in one liter *twice* the quantity of the active reagent in the normal solution.

$\frac{N}{2}$ (*semi-normal*) = Solutions which contain in one liter *one-half* of the quantity of the active reagent in the normal solution.

INDICATORS.

An indicator is a substance which is added to the solutions, during titration, for the purpose of showing, by a change of color (or other visible change), the exact point at which the reaction is complete.

The principal indicators employed are:—

(1) *Solution of Litmus* (Test solution, U. S. P.). This turns red with acids and blue with alkalies.

(2) *Alcoholic Solution of Phenolphtalein* (Test solution U. S. P.). —This is colorless with acids and turns deep red with alkali hydrates and carbonates; bicarbonates and most other salts do not produce this color. It is not reliable when alkaline salts of ammonium or phosphoric acid* are present.

(3) *Solution of Methyl-Orange* (Test solution U. S. P.).—This solution acquires a yellow color in contact with alkali hydrates, carbonates, or bicarbonates. With the inorganic acids the solution acquires a crimson color. It is indifferent to carbonic acid and should not be used with organic acids.

(4) *Solution of Rosolic Acid in diluted alcohol* (Test solution U. S. P.).—The solution turns violet with alkalies and yellow with acids.

(5) *Decoction of Brazil-Wood* (Test solution U. S. P.).—This is a very sensitive indicator, especially adapted in the estimation of alkaloids. The solution turns purplish-red with alkalies, and yellow with acids.

(6) *Tincture of Cochineal* (Test solution U. S. P.).—The solution turns violet with alkalies and yellowish-red with acids. It is employed as an indicator when ammonia or alkaline earths are present.

(7) *Starch Mucilage* (Test solution U. S. P.).—The cold solution turns blue in the presence of free iodine.

(8) *Solution of Potassium Chromate* (Test solution U. S. P.).—The solution gives a red color with silver nitrate. When any halogen salts are present, the red color does not appear until every trace of the halogen has combined with the silver.

(9) *Solution of Potassium Ferricyanide* (Test solution U. S. P.).—This gives a blue color or precipitate with ferrous, and only a clear brown solution with ferric salts. This indicates that all of the ferrous salt has been oxidized to ferric, when it ceases to impart a blue color to the solution.

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* Excepting in case of an orthophosphate M_2HPO_4—See Estimation of Phosphoric Acid.

APPARATUS EMPLOYED.

Measuring Flasks and Cylinders.—For the preparation of volumetric solutions we employ accurately graduated flasks or cylinders. The flasks (Fig. 384) are made of various sizes, usually of the capacity of 250, 500 and 1000 cubic centimeters (at 15° C. or 59° F.), which is indicated by a mark on the neck. Graduated cylinders (Fig. 385) are also employed for this purpose.

Pipettes.—These are instruments (see page 164) graduated to *deliver* definite volumes of fluids. They are constructed to hold,

FIG. 385.

FIG. 384.

Measuring Flasks.

Measuring Cylinder.

when the fluid is drawn up to the mark indicated on the stem, various volumes, as 1 cubic centimeter or fraction thereof, 5, 10, 15, 20, 25 or 50 cubic centimeters.

Burettes.—These are long tubes, usually of a capacity of 25, 50 or 100 cubic centimeters, and graduated into divisions of 1 Cc. or fractions thereof (one-fifths or one-tenths). These are employed for measuring out standard solutions. They are graduated between two points on the cylinder, the upper one (0) beginning a short distance below the upper extremity, the lower one (50 or 100 Cc.) being situated a short distance above the point where the tube begins to narrow toward the outlet; the fluid can be measured only between these points (0 and 50, Fig. 387). The

burettes are usually fitted below with a pinch-cock arrangement (Fig. 386), or with a glass stop-cock (Fig. 388, *a-b*); the former, when pressed, or the latter when turned, allows the fluid to flow out at any speed desired. The pinch-cock arrangement is applied to the simpler forms of burettes in which a short heavy piece of rubber tube is slipped over the narrow neck (*a*, Fig. 386) of the lower end of the burette, and tied, if necessary (*b*, Fig. 386). Into the other end of the rubber tube is slipped a short piece of glass tubing (*d*, Fig. 386) of small caliber, drawn to a fine orifice; between the extremities of the rubber, a pinch-cock* (*c*, Fig. 386) is placed,

FIG. 386.

c

Burette Operated with Pinch-Cock.

FIG. 387.

Device for Dropping from Burette.

FIG. 388.

b

Burettes with Glass Stop-Cocks.

and by pressing the two tips it is caused to open and permit the flow of liquid from the burette. Fig. 387 illustrates the same form, in which the pinch-cock is replaced by a small glass marble, or short rounded piece of glass rod of sufficient size so that when it is inserted inside the tube, it will retain its position and not permit the liquid to pass through. It is operated by pressing the rubber tube slightly together at this point, forming a narrow channel, which permits the fluid to flow out at any rate desired.

Beginners find it at first somewhat difficult to read off the height of the column of fluid correctly. On holding the burette so that the surface of the fluid is on a level with the eye, it

* See also page 90, Figs. 138, 139.

will present an appearance like unto that shown in Fig. 389, this being known as the *meniscus.* It is a matter of some difference, whether the height of the meniscus is read off on a line parallel with the upper edge *o* or the lower one at *u*. But if we begin by reading off from one of these edges, we must use the same height in all our other readings. To facilitate the accuracy of reading, various devices have been proposed; one of the simplest (for clear liquids) is that shown in Fig. 390, in which a piece of paper half black and half white is held against the back of the burette, the upper edge of the black portion being held a few millimeters below the level of the liquid; the lower concave curve of the meniscus then appears as a sharp black line which enables the operator readily to note the height of the fluid.

Fig. 389.

Meniscus.

Fig. 390.

Reading of Meniscus.

Some burettes are specially constructed for the purpose of facilitating reading, being provided with white enameled sides and dark blue background (Fig. 391); the reflection of the dark line in the background with the meniscus produces an appearance as shown in Fig. 392. The point of the narrowest portion corresponds to the middle of the meniscus, which can be read off with great accuracy. A very convenient instrument for avoiding the meniscus altogether, and which can be employed with accuracy for all kinds of fluids, is the Erdmann float (Fig. 393). This consists of a small cylindrical closed tube, sufficiently weighted so that it will float upright, around the middle of which a line is scratched; this is placed in the fluid in the burette and the height is read off by comparing the ring (scratch) on the float with the divisions on the burette.

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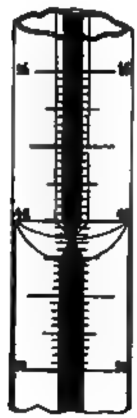
In the operation of titrating, the substance to be titrated, if in dry or concentrated form, should always be dissolved in, or diluted with water. Beakers or flasks, placed on a sheet of white paper, or a porcelain dish should be employed for holding the solution; the operation should be conducted with as much light as possible, in order to distinguish clearly the change of color, etc., which denotes the end point of the reaction. In the beginning of the operation, the standard solution may be added rapidly *under constant stirring*; towards the end it should be added more cautiously, and finally only in drops. Thus in adding a standard solution of an alkali to an acid (diluted), with phenolphtalein as indicator, each drop of the alkali solution will produce a red color which almost immediately disappears. Toward the end of the reaction, however, this red color disappears less rapidly; then the operator should proceed very cautiously. Just sufficient of the reagent should be added to produce the desired color (*not too intense*), or to cause decolorization, as the case may be. With such indicators as phenolphtalein or litmus, which produce marked changes in color, little difficulty is experienced in distinguishing the end-point of the reaction. Other indicators, however, such as methyl-orange, brazil wood, cochineal, etc., cause considerable difficulty for the inexperienced, the change of color being often very gradual and sometimes indistinct. It is best for the operator to take two beakers or test tubes containing the same bulk of water as there is fluid for assay, acidulate one with the standard acid solution, and render the other alkaline to an equal degree; then add to both an equal amount of the indicator. On placing these

FIG. 391.

Burette (Enameled Sides).

FIG. 392.



Effects produced by Meniscus.

FIG. 393.

Erdmann Float.

beside the sample to be assayed the change of color can be accurately noted by comparison.

FIG. 394.

Burette Stand.

FIG. 395.

Burette in Position.

PREPARATION OF STANDARD SOLUTIONS, WITH EXERCISES.

As before stated, these solutions are prepared by dissolving a given weight, that is, usually, the molecular weight of the reagent, expressed in grammes, in 1000 Cc. of water. Thus in order to prepare a standard normal solution of hydrochloric acid, we should weigh off (assuming that we had an acid of the exact strength required) an amount containing 36.37 Gm. of the

absolute acid, place it into a flask, and dilute it with water to one liter. Then

if 1000 Cc. of the solution contain 36.37 Gm. of absolute HCl.
1 Cc. " " " " 0.03637 " " " "

From the equation.

HCl	+	$NaOH$	=	$NaCl$	+	H_2O
Hydrochloric Acid. 36.37		Sodium Hydrate. 39.96		Sodium Chloride.		Water.

we learn that

36.37 Gm. Hydrochloric Acid is equivalent to 39.96 Gm. of Sodium Hydrate
1 Cc. or 0.03637 Gm. " " " " " 0.03996 Gm. of " "
x Cc. of " " " " $x \times 0.03996$ Gm. of " "

If we know the number of cubic centimeters of normal acid solution, the amount of alkali is readily calculated.

The second clause of the definition of Volumetric Solutions reads thus, "and reduced to the valency corresponding to one atom of replaceable hydrogen or its equivalent."

When we desire to prepare a normal sulphuric acid solution we weigh off an amount equivalent to 48.91 Gm. (½ of 96.82) of the absolute acid, and dilute it to one liter; here we have taken *one-half* of the molecular weight, for sulphuric acid, being bivalent, corresponds to *two* atoms of replaceable hydrogen.

Thus

H_2SO_4	+	$2NaOH$	=	Na_2SO_4	+	$2H_2O$
Sulphuric Acid. 97.82		Sodium Hydrate. 2×39.96		Sodium Sulphate.		Water.

One molecule (97.82 p.) of Sulphuric Acid is equivalent to *two* molecules (2×39.96 p.) of Sodium Hydrate.

One-half of a molecule (48.96 p.) of Sulphuric Acid is equivalent to *one* molecule (39.96 p.) of Sodium Hydrate.

1000 Cc. ($\frac{N}{1}$ V. S.) containing 48.91 Gm. Sulphuric Acid = 39.96 Gm. of Sodium Hydrate.

1 Cc. " " 0.04891 Gm. Sulphuric Acid = 0.03996 Gm. of Sodium Hydrate.

x Cc. of normal Sulphuric Acid Solution = $x \times 0.03996$ Gm. of Sodium Hydrate.

The estimation of acids is known as *Acidimetry*, and that of alkalies, *Alkalimetry*. In order to prepare the various standard solutions, we must select some substance which can be readily had in pure and undiluted form. For this purpose crystallized oxalic acid answers best. Its solution must be carefully and accurately prepared, for upon this all other normal acid and alkaline standard solutions are based; hence any inaccuracy in this standard would be carried over into all others.

(1) Normal Oxalic Acid Volumetric Solution.

$H_2C_2O_4 + 2H_2O = 125.7$ 62.85 Gm. in 1 Liter.

Weigh 62.85 Gm.* of pure oxalic acid in crystals and transfer

* "This is frequently rounded off to 63 Gm. when a delicate balance and exact weights are not at hand."

it without loss to a measuring flask or cylinder of one liter capacity, add enough distilled water to dissolve it, then, maintaining the temperature at or near 15° Cc. or 59° F., add water to make the volume measure exactly 1000 cubic centimeters.

One Cubic Centimeter of Normal Oxalic Acid V. S. is the equivalent of:

	Gramme.
Oxalic Acid, crystallized, $H_2C_2O_4 + 2H_2O$	0.06285
Ammonia Gas, NH_3	0.01701
Sodium Hydrate, NaOH	0.03996
Potassium Hydrate, KOH	0.05599
Potassium Permanganate, $KMnO_4$	0.03153

(*a*) *Estimation of Alkali Hydrates.*

Exercise.—In about 30 Cc. of water 0.4 Gm. of Soda were dissolved, with phenolphtalein as indicator; 9 Cc. of normal oxalic acid V. S. were required to neutralize it (sufficient to discharge the pink color): What was its percentage in pure NaOH?

According to the equation.

$H_2C_2O_4 + 2H_2O$	+	$2NaOH$	=	$Na_2C_2O_4$	+	$4H_2O$
Oxalic Acid. 125.7		Sodium Hydrate. 2×39.96		Sodium Oxalate.		Water.

1000 Cc. ($\frac{N}{1}$ V. S.) containing 62.85 Gm. of Oxalic Acid are equivalent to 39.96 Gm. of Sodium Hydrate.

1 Cc. " " 0.06285 Gm. of Oxalic Acid is equivalent to 0.03996 Gm. of Sodium Hydrate.

9 Cc. of the normal Oxalic Acid, V. S. $= 9 \times 0.03996 = 0.3576 +$ Gm. of Sodium Hydrate.

That is, 0.4 Gm. of the Soda taken contains 0.3576 Gm. of pure substance, hence $0.4 : 0.3576 = 100 : x;\ x = 89.4$ per cent.

(2) Decinormal Oxalic Acid Volumetric Solution.

$H_2C_2O_4 + 2H_2O = 125.7.$ 6.285 Gm.* in 1 Liter.

Dissolve 6.285 Gm.* of pure oxalic acid in enough water to make, at or near 15° C. (59° F.), exactly 1000 Cc.

One Cubic Centimeter of Decinormal Oxalic Acid V. S. is the equivalent of :—

	Gramme.
Oxalic Acid, crystallized, $H_2C_2O_4 + 2H_2O$	0.006285
Ammonia Gas, NH_3	0.001701
Calcium Hydrate, $Ca(OH)_2$	0.003691
Potassium Hydrate, KOH	0.005599
Potassium Permanganate, $KMnO_4$	0.0031534
Sodium Hydrate, NaOH	0.003996

The decinormal solution is generally preferred to the normal, because the stronger solution has the tendency to crystallize at the point of the burette, in consequence of which particles of the solid matter are liable to drop into the solution to be assayed.

* "Generally rounded off to 6.3 Gm., when a delicate balance and exact weights are not available."

ALKALIMETRY.

Any of the normal or decinormal acid solutions may be employed for estimating the strength of alkalies or alkaline solutions. The substance or fluid is quickly weighed, dissolved or mixed with the necessary volume of water, then a few drops of phenolphtalein solution are added, or in presence of carbonates, methyl-orange solution, and the standard acid solution then added until the red color of the former just disappears or the yellow color of the latter changes to red. Great care must be employed not to add any more of the reagent than just necessary to produce or discharge a given color.

Exercise.—50 Cc. of Solution of Lime (Lime Water), with phenolphtalein as indicator, required 20 Cc. of decinormal oxalic acid V. S., for complete neutralization (sufficient to discharge the pink color). What percentage of Calcium Hydrate does the solution contain?

According to the equation:—

$$\underset{\substack{\text{Oxalic Acid.}\\125.7}}{H_2C_2O_4 + 2H_2O} \quad + \quad \underset{\substack{\text{Calcium Hydrate.}\\73.83}}{Ca(OH)_2} \quad = \quad \underset{\text{Calcium Oxalate.}}{CaC_2O_4} \quad + \quad \underset{\text{Water.}}{4H_2O}$$

125.7 parts of Oxalic Acid are equivalent to 73.83 parts of Calcium Hydrate
62.85 parts of Oxalic Acid are equivalent to 36 91 + parts of Calcium Hydrate.
1000 Cc. ($\frac{N}{10}$ V. S.) containing 6.285 Gm. of Oxalic Acid are equivalent to 3.691 + Gm. of Calcium Hydrate.
1 Cc. " " " 0.006285 Gm. of Oxalic Acid is equivalent to 0.003691 + Gm. of Calcium Hydrate.
20 Cc. of the decinormal Oxalic Acid, V. S. = 20 × 0.003691 + = 0.07382 + Gm. of Calcium Hydrate.

That is, 0.07382 + Gm. of Calcium Hydrate is contained in 50 Cc. (about 50 Gm.) of Solution of Lime, hence 50 : 0.0738 = 100 : x; x = 0.14 per cent.

True percentage by weight would require that the specific gravity of the solution be taken into consideration. In this case, where it is practically identical with that of water, it may be neglected.

Inasmuch as sulphuric acid varies in strength, and the accurate weighing of quantities corresponding to definite amounts of absolute acid is next to impossible, the strength of a diluted acid is adjusted by means of a standard solution of potassium hydrate, which in turn owes its accuracy to having been standardized by oxalic acid (see Normal Potassium Hydrate V. S., page 426). The Pharmacopœia gives the following directions:—

(3) Normal Sulphuric Acid.

H_2SO_4 = 97.82. 48.91 Gm. in 1 Liter.

"Carefully mix 30 Cc. of pure, concentrated sulphuric acid (of specific gravity 1.835) with enough water to make about 1050 Cc., and allow the liquid to cool to about 15° C. (59° F.). Place 10 Cc. of this liquid (which is yet too concentrated) into a flask, add

a few drops of phenolphtalein T. S., and afterwards, from a burette, normal potassium hydrate V. S., shaking after each addition, and regulating the flow to drops towards the end of the operation, until the red color produced by its influx no longer disappears on shaking, but is not deeper than pale pink. Note the number of Cc. of potassium hydrate V. S. consumed. Then dilute the sulphuric acid solution so that equal volumes of this and of normal potassium hydrate V. S. exactly neutralize each other.

Example.—Assuming that 10 Cc. of the acid solution first prepared had required exactly 11.2 Cc. of normal potassium hydrate V. S., each 10 Cc. of the former must be diluted to 11.2 Cc., or each 1000 Cc. to 1120 Cc.

After the liquid is thus diluted, a new trial should be made in the manner above described, in which 50 Cc. of the acid solution should require for neutralization exactly 50 Cc. of potassium hydrate V. S. If necessary, a new adjustment should be made to render the correspondence perfect."

One Cubic Centimeter of Normal Sulphuric Acid is the equivalent of:

	Gramme.
Sulphuric Acid, absolute, H_2SO_4	0.04891
Ammonia Gas, NH_3	0.01701
Ammonium Carbonate, $(NH_4)_2CO_3$	0.042935
Ammonium Carbonate [U. S. P.], $NH_4HCO_3.NH_4NH_2CO_2$	0.05226
Lead Acetate, crystallized, $Pb(C_2H_3O_2)_2 + 3H_2O$	0.18900
Lead Subacetate, assumed as $Pb_2O(C_2H_3O_2)_2$	0.13662
Lithium Benzoate, $LiC_7H_5O_2$ (to be ignited),	0.12772
Lithium Carbonate, Li_2CO_3	0.036935
Lithium Citrate, $Li_3C_6H_5O_7$ (to be ignited),	0.0698566
Lithium Salicylate, $LiC_7H_5O_3$ (to be ignited),	0.14368
Potassium Acetate, $KC_2H_3O_2$ (to be ignited),	0.09789
Potassium Bicarbonate, $KHCO_3$	0.09988
Potassium Bitartrate, $KHC_4H_4O_6$ (to be ignited),	0.18767
Potassium Carbonate, anhydrous, K_2CO_3	0.068955
Potassium Citrate, cryst., $K_3C_6H_5O_7 + H_2O$ (to be ignited),	0.10786
Potassium Hydrate, KOH	0.05599
Potassium and Sodium Tartrate, $KNaC_4H_4O_6 + 4H_2O$ (to be ignited),	0.14075
Sodium Acetate, $NaC_2H_3O_2 + 3H_2O$ (to be ignited),	0.13574
Sodium Benzoate, $NaC_7H_5O_2$ (to be ignited),	0.14371
Sodium Bicarbonate, $NaHCO_3$	0.08385
Sodium Borate, crystallized, $Na_2B_4O_7 + 10H_2O$	0.19046
Sodium Carbonate, anhydrous, Na_2CO_3	0.052925
Sodium Carbonate, crystallized, $Na_2CO_3 + 10H_2O$	0.142725
Sodium Hydrate, NaOH	0.03996
Strontium Lactate, $Sr(C_3H_5O_3)_2$ (to be ignited),	0.13244

Exercise.—Exactly 1.7 Gm. of Stronger Ammonia Water was diluted with water, rosolic acid added as indicator, and normal solution of sulphuric acid added until the violet-red color gave way to yellow, 28 Cc. of the normal solution having been consumed. What is the percentage strength in ammonia gas?

H_2SO_4	+	$2NH_3.H_2O$	=	$(NH_4)_2SO_4$	+	$2H_2O$
Sulphuric Acid. 97.82		Ammonia Water. 2×17		Ammonium Sulphate.		Water.

1000 Cc. ($\frac{N}{1}$ V. S.) containing 48.91 Gm. of Sulphuric Acid are eqvivalent to 17 Gm. of Ammonia Gas.
1 Cc. " " " 0.04891 Gm. of Sulphuric Acid is equivalent to 0.017 Gm. of Ammonia Gas.

28 Cc. of normal Sulphuric Acid V. S. $= 28 \times 0.017 = 0.476$ Gm. Ammonia Gas. Since 1.7 Gm. of Ammonia Water has been taken, then $1.7 : 0.476 = 100 : x$; $x = 28$ per cent.

(*b*) *Estimation of Alkali Carbonates.*

Exercise.—Let it be assumed that two samples of sodium bicarbonate, each of 0.85 Gm. are to be assayed, to determine the percentage of pure salt.

Here it should be stated that two methods are available for assaying alkalies in presence of carbonic acid. One is the cold method, with methyl-orange as indicator, since this is not sensitive to carbonic acid. The other is the hot method, with phenolphtalein as indicator, which will not strike a pink color with alkalies, until all the carbonic acid has been expelled by heat.

Let it now also be assumed that we used the *cold* process, with methyl-orange, on one sample, and the *hot* process, with phenolphtalein on the other, and that, in both cases, 10 Cc. of normal sulphuric acid were required to produce neutrality.

(1) *Cold Process.*—The procedure is the same as in all solutions heretofore explained.

H_2SO_4	+	$2NaHCO_3$	=	Na_2SO_4	+	CO_2	+	H_2O
Sulphuric Acid. 97.82		Sodium Bicarbonate. 2×83.85		Sodium Sulphate.		Carbonic Acid Gas.		Water.

1000 Cc. ($\frac{N}{1}$ V. S.) containing 48.91 Gm of Sulphuric Acid are equivalent to 83.85 Gm. of Sodium Bicarbonate.
1 Cc. " " " 0.04891 Gm. of Sulphuric Acid is equivalent to 0.08385 Gm. of Sodium Bicarbonate.
10 Cc. of normal Sulphuric Acid, V. S. $= 10 \times 0.08385 = 0.835 +$ Gm. pure Sodium Bicarbonate.

That is, 0.850 Gm. of the Sodium Bicarbonate taken contains 0.835 Gm. of pure substance, hence $0.850 : 0.835 = 100 : x$; $x = 98.2$ per cent.

(2) *Hot Process.*—When phenolphtalein is used as indicator, the solution will have to be boiled after the addition of each instalment of the standard acid solution in order to expel the carbonic acid. The end of the reaction is recognized from the fact that the red color produced by the indicator with alkalies ceases to reappear after several minutes boiling.

(*c*) *Estimation of Organic Salts of the Alkalies and Alkali Earths.*

The organic salts of potassium, sodium, lithium, strontium, etc., are examined by weighing out a small amount in a platinum or porcelain crucible, then heating slowly to redness (uncovered) until no further gases are given off and a charred mass remains. The crucible is allowed to cool, and its contents treated with boiling water and filtered into a flask or porcelain dish. The crucible is washed out with boiling water, and the washings passed through

the filter, until the filtrate ceases to turn red litmus blue. To the filtrate, which should be clear, a sufficient amount of the indicator is added; and the alkali carbonate present estimated as directed above. This method is directed by the U. S. Pharmacopœia to be carried out with Lithium Benzoate, Lithium Citrate, Lithium Salicylate, Potassium Acetate, Potassium Bitartrate, Potassium Citrate, Potassium et Sodium Tartrate, Sodium Acetate, Sodium Benzoate and Strontium Lactate.

POTASSII BITARTRAS.

* $2KHC_4H_4O_6$	=	K_2CO_3	+	5C	+	$2CO_2$	+	$5H_2O$
Potassium Bitartrate. 2 × 187.67		Potassium Carbonate. 138		Carbon.		Carbonic Acid Gas.		Water.

H_2SO_4	+	K_2CO_3	=	K_2SO_4	+	CO_2	+	H_2O
Sulphuric Acid. 97.82		Potassium Carbonate. 138		Potassium Sulphate.		Carbonic Acid Gas.		Water.

1000 Cc. $\frac{N}{1}$ V. S. containing 48.91 Gm. of Sulphuric Acid is equivalent to 69 Gm. of Potassium Carbonate.
1 Cc. " " " 0.04891 Gm. of Sulphuric Acid is equivalent to .069 Gm. of Potassium Carbonate.

One molecule (138 parts) of Potassium Carbonate is obtained from two molecules (2 × 187.67 parts) of Potassium Bitartrate, hence one-half of a molecule (69 parts) of the former is obtained from one molecule (187.67 parts) of the latter. Then each 1 Cc. of normal Sulphuric Acid V. S. is equivalent to 0.069 Gm. Potassium Carbonate, which in turn represents 0.187 + Gm. Potassium Bitartrate.

POTASSII ET SODII TARTRAS.

† $2(KNaC_4H_4O_6 + 4H_2O)$	=	$2KNaCO_3$	+	5C	+	CO_2	+	$12H_2O$
Rochelle Salt. 2 × 281.5		Potassium Sodium Carbonate. 2 × 122		Carbon.		Carbonic Acid Gas.		Water.

$KNaCO_3$	+	H_2SO_4	=	$KNaSO_4$	+	CO_2	+	H_2O
Potassium Sodium Carbonate. 122		Sulphuric Acid. 97.82		Potassium Sodium Sulphate.		Carbonic Acid Gas.		Water.

1000 Cc. ($\frac{N}{1}$ V. S.) containing 48.91 Gm. of Sulphuric Acid are equivalent to 61 Gm. of Potassium Sodium Carbonate.
1 Cc. " " " 0.04891 Gm. of Sulphuric Acid is equivalent to 0.061 Gm. Potassium Sodium Carbonate.

One molecule (122 parts) of Potassium Sodium Carbonate is obtained from one molecule (281.5 parts) of Rochelle Salt. Then each 1 Cc. of normal Sulphuric Acid V. S. is equivalent to 0.061 Gm. Potassium Sodium Carbonate, which in turn represents 0.1407 + Gm. of Rochelle Salts.

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* The reaction may also be written thus:
$2KHC_4H_4O_6 + 5O_2 = K_2CO_3 + 7CO_2 + 5H_2O.$

† The reaction may also be written thus:
$2KNaC_4H_4O_6.4H_2O + 5O_2 = 2KNaCO_3 + 6CO_2 + 12H_2O$

SODII BENZOAS.

$2NaC_7H_5O_2$	+	$5O_2$	=	Na_2CO_3	+	$5H_2O$	+	$3CO_2$	+	$5C_2$
Sodium Benzoate. 2×143.71		Oxygen.		Sodium Carbonate. 138		Water.		Carbonic Acid Gas.		Carbon.

H_2SO_4	+	Na_2CO_3	=	Na_2SO_4	+	CO_2	+	H_2O
97.82		138						

One Cc. of normal Sulphuric Acid V. S. containing 0.04891 Gm. of Acid is equivalent to 0.069 Gm. of Sodium Carbonate.

One molecule (138 parts) of Sodium Carbonate is obtained from two molecules (2×143.71 parts) of Sodium Benzoate, or one-half of a molecule (69 parts) of the former is equivalent to one molecule (143.71 parts) of the latter.

Then 1 Cc. of normal Sulphuric Acid V. S. is equivalent to 0.069 Gm. of Sodium Carbonate, which in turn represents 0.1437 + Gm. of Sodium Benzoate.

(4) NORMAL HYDROCHLORIC ACID SOLUTION is made after the same principle and is in every respect equivalent, in neutralizing power, to normal Sulphuric Acid. It may be employed in all instances given under the latter.

$H_2C_2O_4 + 2H_2O$	=	H_2SO_4	=	$2HCl$
Oxalic Acid. 125.7		Sulphuric Acid. 97.83		Hydrochloric Acid. 2×36.37

1 L. of $\frac{N}{1}$ V. S. containing 62.85 Gm. Oxalic Acid = 1 L. containing 48.91 Gm. of H_2SO_4.
1 Cc. " " " 0.06285 Gm. Oxalic Acid = 1 Cc. containing 0.4891 Gm. of H_2SO_4.
1 L. of $\frac{N}{1}$ Sulphuric Acid = 1 L. containing 36.37 Gm. Hydrochloric Acid.
1 Cc. " " " " = 1 Cc. " 0.03637 Gm. " "

(5) NORMAL POTASSIUM HYDRATE VOLUMETRIC SOLUTION.

KOH = 55.99. 55.99 Gm.* in 1 Liter.

"Dissolve 75 Gm. of potassium hydrate [*Potassa*, U. S. P.] in enough water to make, at or near 15° C. (59° F.), about 1050 Cc., and fill a burette with a portion of this liquid.

Put 0.6285 Gm.† of pure oxalic acid into a flask of the capacity of about 100 Cc., and dissolve it with about 10 Cc. of water. Add a few drops of phenolphtalein T. S., and then carefully add, from the burette, the potassium hydrate solution, frequently agitating the flask, and regulating the flow to drops toward the end of the operation, until the red color produced by the influx no longer disappears on shaking, but is not deeper than pale pink. Note the number of Cc. of the potassium hydrate solution consumed, and then dilute the remainder of the solution so that exactly 10 Cc. of the diluted liquid shall be required to neutralize 0.6285 Gm.† of oxalic acid.

Example.—Assuming that 8.0 Cc. of the stronger solution of potassium hydrate first prepared had been consumed in the trial,

* "This figure is frequently rounded off to 56 Gm."

† This figure may be rounded off to 0.63 Gm., if a delicate balance and exact weights are not available.

then each 8.0 Cc. must be diluted to 10 Cc., or the whole of the remaining solution in the same proportion. Thus, if 1000 Cc. should be still remaining, this must be diluted with water to 1250 Cc.

After the liquid is thus diluted, a new trial should be made in the manner above described, in which 10 Cc. of the diluted solution should exactly neutralize 0.6285 Gm.* of oxalic acid. If necessary, a new adjustment should then be made to render the correspondence perfect.

Note.—Solutions of caustic alkalies are very prone to absorb carbon dioxide from the atmosphere, and thereby become liable to occasion errors when used with litmus T. S. or phenolphtalein T. S. as indicators (methyl-orange T. S. is not affected by the presence of carbonic acid). Hence the volumetric solutions should be preserved in small vials provided with well-fitting corks or rubber stoppers, or, better still, they should have tubes filled with a mixture of soda and lime attached to their stoppers, so as to absorb the carbon dioxide and prevent its access to the solution.

In place of potassium hydrate V. S., sodium hydrate V. S. may be used, in the same manner and in the same quantity. Potassium hydrate V. S., however, is preferable, since it foams less, and attacks glass more slowly and less energetically."

One Cubic Centimeter of Normal Potassium Hydrate V.S. is the equivalent of:

	Gramme.
Potassium Hydrate, KOH	0.05599
Sodium Hydrate, $NaOH$	0.03996
Ammonia Gas, NH_3	0.01701
Ammonium Chloride, NH_4Cl	0.05338
Acetic Acid, absolute, $HC_2H_3O_2$	0.05986
Citric Acid, crystallized, $H_3C_6H_5O_7 + H_2O$	0.06983
Hydrobromic Acid, absolute, HBr	0.08076
Hydrochloric Acid, absolute, HCl	0.03637
Hydriodic Acid, absolute, HI	0.12753
Hypophosphorous Acid, HPH_2O_2	0.06588
Lactic Acid, absolute, $HC_3H_5O_3$	0.08979
Nitric Acid, absolute, HNO_3	0.06289
Oxalic Acid, crystallized, $H_2C_2O_4 + 2H_2O$	0.06285
Phosphoric Acid, H_3PO_4 (to form K_2HPO_4; with phenolphtalein),	0.0489
Phosphoric Acid, H_3PO_4 (to form KH_2PO_4; with methyl-orange),	0.0978
Potassium Dichromate, $K_2Cr_2O_7$	0.14689
Sulphuric Acid, absolute, H_2SO_4	0.04891
Tartaric Acid, crystallized, $H_2C_4H_4O_6$	0.07482

ACIDIMETRY.

The necessary amount of fluid (acid) should be weighed off in a tared and stoppered weighing flask, in order to avoid injury or corrosion of the balances. It is not always advisable to attempt

* This figure may be rounded off to 0.63 Gm., if a delicate balance and exact weights are not available.

to weigh off a definite amount of the fluid, as this is attended with considerable difficulty. It is better to measure a quantity of the fluid, by means of a pipette, into a flask and then weigh the amount. The amount of acid selected depends upon its strength. For this purpose the Pharmacopœia tabulates a list of various acids, stating the amount to be taken. Any weight approximately near that given may be selected. It is best to avoid taking large amounts of the acids, as this would result in the useless waste of a large volume of the standard alkali solution.

After weighing off the acid, the contents of the weighing flask are carefully rinsed out into a beaker or other flask preparatory to titrating. Then a few drops of the indicator are added, and titration carried out with normal alkali solution until the fluid turns faint rose red (with phenolphtalein), or blue (with litmus), or yellow (with methyl-orange), or faint violet red (with rosolic acid), etc.

The following equations will explain the various equivalents of the acids.

$$(a)\quad \underset{55.9}{KOH} + \underset{36.37}{HCl} = KCl + H_2O$$

0.0559 Gm. of Potassium Hydrate (1 Cc.) are equivalent to 0.03637 Gm. of absolute Hydrochloric Acid.

$$(b)\quad \underset{55.9}{KOH} + \underset{59.86}{HC_2H_3O_2} = KC_2H_3O_2 + H_2O$$

0.0559 Gm. of Potassium Hydrate (1 Cc.) are equivalent to 0.05986 Gm. of absolute Acetic Acid.

$$(c)\quad \underset{\substack{2 \times 55.9 \\ 55.9\ p.}}{2KOH} + \underset{\substack{97.82 \\ = 48.91\ p.}}{H_2SO_4} = K_2SO_4 + 2H_2O$$

0.0559 Gm. of Potassium Hydrate (1 Cc.) are equivalent to 0.04891 Gm. of absolute Sulphuric Acid.

$$(d)\quad \underset{\substack{2 \times 55.9 \\ 55.9\ p.}}{2KOH} + \underset{\substack{149.64 \\ = 74.82\ p.}}{H_2C_4H_4O_6} = K_2C_4H_4O_6 + 2H_2O$$

0.0559 Gm. of Potassium Hydrate (1 Cc.) are equivalent to 0.07482 Gm. of crystallized Tartaric Acid.

$$(e)\quad \underset{\substack{3 \times 55.9 \\ 55.9\ p.}}{3KOH} + \underset{\substack{209.5 \\ = 69.83\ p.}}{H_3C_6H_5O_7} + H_2O = K_3C_6H_5O_7 + 4H_2O$$

0.0559 Gm. of Potassium Hydrate (1 Cc.) are equivalent to 0.06983 Gm. of crystallized Citric Acid.

$$(f)\quad \underset{\substack{2 \times 55.9 \\ 55.9}}{2KOH} + \underset{\substack{97.8 \\ = 48.9}}{H_3PO_4} = K_2HPO_4 + 2H_2O$$

In the case of phosphoric acid, with phenolphtalein as indicator, neutralization is attained when potassium orthophosphate (K_2HPO_4) is formed, which requires two molecules of alkali.

0.0559 Gm. of Potassium Hydrate (1 Cc.) are equivalent to 0.0489 Gm. of Phosphoric Acid.

$$(g)\quad \underset{55.9}{KOH} + \underset{97.8}{H_3PO_4} = KH_2PO_4 + H_2O$$

With methyl-orange as indicator, neutralization is attained

when acid potassium phosphate (KH_2PO_4) is formed, which requires one molecule of alkali.

0.0559 Gm. of Potassium Hydrate (1 Cc.) are equivalent to 0.0978 Gm. of Phosphoric Acid.

(6) CENTINORMAL POTASSIUM HYDRATE V. S. containing 0.5599 Gm. to the liter, or 0.0005599 Gm. to the cubic centimeter, is employed in conjunction with *decinormal sulphuric acid* V. S. (containing 0.004891 Gm. in the cubic centimeter) in the estimation of total alkaloids in Extract of Nux Vomica.

10 Cc. $\frac{N}{100}$ Potassium Hydrate (0.005599 Gm.) is equivalent to 1Cc. $\frac{N}{10}$ Sulphuric Acid (0.004891 Gm.).

Deci and centinormal solutions are employed for the determination of minute quantities of acids or alkalies. Because of their great dilution, we are enabled to measure off volumes representing exceedingly small quantities of the actual reagent, which under ordinary circumstances, would be impossible with a burette of the usual graduations. Since the solutions are very dilute, an error of a tenth or fifth of a cubic centimeter would not affect the result, which would be the case, however, were we to employ a *normal* solution which is 100 times as strong.

(7) DECINORMAL SILVER NITRATE VOLUMETRIC SOLUTION.

$AgNO_3 = 169.55$. 16.955 Gm.* in 1 Liter.

The U. S. Pharmacopœia gives the following directions:—

Dissolve 16.955 Gm.* of pure silver nitrate in enough water to make, at or near 15° C. (59° F.), exactly 1000 Cc.

Keep the solution in small, dark amber-colored, glass-stoppered vials, carefully protected from dust.

Note.—Titration by decinormal silver nitrate V.S. may be managed in various ways, adapted to the special preparation to be tested.

a. In most cases it is directed by the U. S. P. to be used in presence of a small quantity of potassium chromate T. S., which serves to indicate the end of the reaction by the appearance of the red color of silver chromate.

b. In some cases (potassium cyanide, hydrocyanic acid) it is added until the first appearance of a permanent precipitate.

One Cubic Centimeter of Decinormal Silver Nitrate V. S. is the equivalent of:

	Gramme.
Silver Nitrate, $AgNO_3$	0.016955
Ammonium Bromide, NH_4Br	0.009777
Ammonium Chloride, NH_4Cl	0.005338
Calcium Bromide, $CaBr_2$	0.0099715
Ferrous Bromide, $FeBr_2$	0.010770
Ferrous Iodide, FeI_2	0.015447

* "Frequently rounded off to 16.96 Gm., when a delicate balance and exact weights are not available."

	Gramme.
Hydrocyanic Acid, absolute, HCN, with indicator,	0.002698
Hydrocyanic Acid, absolute, HCN, to first formation of precipitate,	0.005396
Hydriodic Acid, HI	0.012753
Hydrobromic Acid, HBr	0.008076
Lithium Bromide, LiBr	0.008677
Potassium Bromide, KBr	0.011879
Potassium Chloride, KCl	0.007440
Potassium Cyanide, KCN with indicator,	0.006501
Potassium Cyanide, KCN, to first formation of precipitate,	0.013002
Potassium Iodide, KI	0.016556
Potassium Sulphocyanate, KSCN	0.009699
Sodium Bromide, NaBr	0.010276
Sodium Chloride, NaCl	0.005837
Sodium Iodide, NaI	0.014953
Strontium Bromide, $SrBr_2$ (anhydrous),	0.012341
Strontium Iodide, SrI, (anhydrous),	0.017018
Zinc Bromide, $ZnBr_2$	0.011231
Zinc Chloride, $ZnCl_2$	0.006792
Zinc Iodide, ZnI_2	0.015908

Exercise.—An unknown quantity of pure sodium chloride was dissolved in water in a beaker, a few drops of potassium chromate were added to impart a yellow color, then the silver solution was slowly run in, under constant stirring, until the last drop caused the solution to turn permanently pale reddish (silver chromate); 30 Cc. of silver solution were required. How much sodium chloride was present?

(a) $AgNO_3$	+	NaCl	=	AgCl	+	$NaNO_3$
Silver Nitrate. 169.55		Sodium Chloride. 58.37		Silver Chloride.		Sodium Nitrate.

1000 Cc. ($\frac{N}{10}$ V.S.) containing 16.955 Gm. of Silver Nitrate are equivalent to 5.837 Gm. of Sodium Chloride.

1 Cc. " " 0.016955 " of Silver Nitrate is equivalent to 0.005837 Gm. of Sodium Chloride.

30 Cc. Silver Nitrate = 30 × 0.005837 = 0.175 + Gm. of Sodium Chloride.

Potassium Bromide.

(b) $AgNO_3$	+	KBr	=	AgBr	+	KNO_3
169.55		118.8				

1000 Cc. ($\frac{N}{10}$ V. S) containing 16.955 Gm. Silver Nitrate are equivalent to 11.88 Gm. Potassium Bromide.

1 Cc. " " " 0.01695 Gm. Silver Nitrate is equivalent to 0.0118 Gm. Potassium Bromide.

Hence each cubic centimeter of the decinormal silver nitrate V. S. is equivalent to 0.01188 Gm. of Potassium Bromide.

The other halogen salts are estimated in the same manner. The halogen acids (HI or HBr) must be first neutralized with an alkali (see Syrupus Acidi Hydriodici, page 278).

Ferrous Iodide cannot be estimated directly like the above halogen salts, because the indicator, potassium chromate, reacts with the ferrous salt (see Syrupus Ferri Iodidi, page 281); hence we have recourse to another method, known as Volhard's, which is equally applicable to the estimation of all halogens.

(7) VOLHARD'S METHOD.

This is applicable where the chromatic indicator cannot be used. It may also be used in the presence of nitric acid, thus enabling us to estimate chlorides in the presence of phosphoric or other acids which precipitate silver in neutral solution. The method depends upon entirely precipitating the halogen, in the presence of nitric acid, by a known excess of standard solution of silver, then estimating the excess of silver left uncombined with the halogen, by a standard solution of potassium (or ammonium) sulphocyanate,* using a drop or so of ferric ammonium sulphate as indicator. As soon as the sulphocyanate has precipitated all of the silver excess, it strikes a blood-red color with the ferric salt, due to the formation of ferric sulphocyanate. The difference between the volume of standard silver solution originally added, and that of the sulphocyanate used, will give the number of cubic centimeters of silver equivalent to the chloride present.

ESTIMATION OF HYDROCYANIC ACID.

(*a*) *To First Formation of a Precipitate.*

The hydrocyanic acid is weighed off, diluted with water, and solution of sodium hydrate added until the liquid is strongly alkaline, as shown by litmus paper or solution. Then decinormal silver nitrate solution is slowly dropped in with constant agitation until a *faint permanent cloud* of silver cyanide (AgCN) is produced. If during the operation, the litmus becomes red, more of the sodium hydrate must be added until the indicator shows a blue tint.

The reaction is as follows:—

$2HCN$	+	$2NaOH$	=	$2NaCN$	+	$2H_2O$
Hydrocyanic Acid.		Sodium Hydrate.		Sodium Cyanide.		Water.
2 × 26.98				2 × 49		

The sodium hydrate is added, to prevent the liberation of free nitric acid which would prevent the silver cyanide from precipitating:—

$2NaCN$	+	$AgNO_3$	=	$AgCN.NaCN$	+	$NaNO_3$
Sodium Cyanide.		Silver Nitrate.		Double Cyanide of Silver and Sodium.		Sodium Nitrate.
2 × 49		169.55				

Two molecules of Hydrocyanic Acid (53.96 parts) are equivalent to *one* molecule of Silver Nitrate (169.55 parts).

Or 5.396 parts of Hydrocyanic Acid are equivalent to 16.955 parts of Silver Nitrate.
Or 0.005396 " " " " " " 0.016955 " " "

Therefore 1 Cc. of $\frac{N}{10}$ Silver Nitrate V. S. (containing 0.016955 Gm. of the salt) is equivalent to 0.005396 Gm. of Hydrocyanic Acid.

---

* $KSCN$	+	$AgNO_3$	=	$AgSCN$	+	KNO_3
Potassium Sulphocyanate.		Silver Nitrate.		Silver Sulphocyanate.		Potassium Nitrate.
96.99		169.55				

Potassium Sulphocyanate, 9.699 Gm. = 16.955 Gm. (1000 Cc. $\frac{N}{10}$ V. S.) Silver Nitrate.

" " 0.009699 Gm. = 0.016955 Gm. (1 Cc. $\frac{N}{10}$ V. S.) " "

Then 1 Cc. of the Sulphocyanate solution (containing 0.009699 Gm. of the salt) is equivalent to 1 Cc. of the Silver Nitrate Solution (containing 0.016955 Gm. of the salt).

(b) *Estimation with Indicator.*

The Pharmacopœia directs that sufficient magnesia paste be added to the weighed and diluted acid to impart an opaque milkiness to the liquid. This serves to neutralize the acid as well as to afford a better opportunity to distinguish the red color (silver chromate) which indicates the end point of the reaction, potassium chromate being the indicator.

The reaction is the same as in the preceding:—*

$2NaCN$	+	$AgNO_3$	=	$AgCN.NaCN$	+	$NaNO_3$
Sodium Cyanide.		Silver Nitrate.		Double Cyanide of Silver and Sodium.		Sodium Nitrate.

$$AgCN.NaCN + AgNO_3 = 2AgCN + NaNO_3$$

$2NaCN$ or $2HCN$ are then equivalent to $2AgNO_3$
2×49 2×26.98 2×169.55

49 parts of Sodium Cyanide or 26.98 parts of Hydrocyanic acid are equivalent to 169.55 parts of Silver Nitrate.
or 4.9 parts of Sodium Cyanide or 2.698 parts of Hydrocyanic acid are equivalent to 16.955 parts of Silver Nitrate.

1000 Cc. of $\frac{N}{10}$ silver solution containing 16.955 Gm. $AgNO_3$ are equivalent to 4.9 Gm. of sodium cyanide, which is equivalent to 2.698 Gm. of hydrocyanic acid. Therefore 1 Cc. of $\frac{N}{10}$ silver solution (0.016955 Gm. of the salt) is equivalent to 0.002698 Gm. of hydrocyanic acid.

POTASSIUM CYANIDE is estimated in the same manner and subjected to the same reactions as given above.

(8) DECINORMAL IODINE VOLUMETRIC SOLUTION.

$I = 126.53$ 12.653 Gm.† in 1 Liter.

Dissolve 12.653 Gm. of pure iodine in a solution of 18 Gm. of pure potassium iodide in 300 Cc. of water; then add enough water to make the solution measure, at or near 15° C. (59° C.), exactly 1000 Cc.

The potassium iodide plays the part of a solvent for the iodine.

One Cubic Centimeter of Decinormal Iodine V. S. is the equivalent of:

	Gramme.
Iodine, I	0.012653
Arsenic Trioxide (arsenous acid), As_2O_3	0.004942
Potassium Sulphite, crystallized, $K_2SO_3 + 2H_2O$	0.009692
Sodium Bisulphite, $NaHSO_3$	0.005193
Sodium Hyposulphite (Thiosulphite) crystals, $Na_2S_2O_3 + 5H_2O$	0.024764
Sodium sulphite, crystallized, $Na_2SO_3 + 7H_2O$	0.012579
Sulphur Dioxide, SO_2	0.003195
Antimony and Potassium Tartrate, crystals, $2K(SbO)C_4H_4O_6 + H_2O$	0.01656.

* For the sake of uniformity and clearness sodium is retained in the explanatory formula instead of magnesium.

† May be rounded off to 12.65 Gm.

(*a*) *Estimation of Arsenous Oxide.*

The arsenous oxide is weighed off and dissolved in boiling water with the aid of sodium bicarbonate. The solution is allowed to cool, some starch paste added, and iodine solution run in until a faint, permanently blue color is obtained. The addition of iodine to arsen*ous* acid in alkaline solution causes its oxidation to arsen*ic* acid, the iodine being thereby converted into hydriodic acid, with disappearance of color. As soon as all of the arsen*ous* acid is oxidized to arsen*ic* acid, the next drop of iodine (being free) will strike a blue color with the starch.

The excess of sodium bicarbonate serves the purpose of combining with the liberated hydriodic acid, which, if present in free condition, would interfere with the reaction:—

As_2O_3	+	$4I$	+	$4NaHCO_3$	=	As_2O_5	+	$4NaI$	+	$4CO_2$	+	$2H_2O$
Arsenous Oxide. 197.68		Iodine. 4 × 126.5		Sodium Bicarbonate.		Arsenic Oxide.		Sodium Iodide.		Carbonic Acid Gas.		Water.

Since *four* molecules of iodine (4 × 126.5) are necessary to oxidize *one* molecule (197.68) of arsen*ous* to arsen*ic* oxide, hence, *one* atom of iodine is equivalent to *one-fourth* of a molecule of arsenous oxide:—

	Iodine.	Arsenous Oxide.
	126.5 p., ...	. 49.42 p.
1000 Cc. $\frac{N}{10}$ V. S. containing	12.65 Gm., ...	. 4.942 Gm.
1 Cc. " "	0.01265 Gm., ...	. 0.004942 Gm.

Therefore each Cc. of $\frac{N}{10}$ Iodine Solution is equivalent to 0.004942 Gm. Arsenous Oxide.

(*b*) *Estimation of Sulphurous Acid, Free and in Sulphites.*

The acid or sulphite is largely diluted with water, starch paste added, then iodine solution added until a faint permanent blue appears. The sulphurous oxide or sulphite undergoes oxidation to sulphuric acid or to sulphate, and the iodine is thereby converted into hydriodic acid according to the equation:—

I_2	+	H_2O	+	$SO_2.H_2O$	=	H_2SO_4	+	$2HI$
Iodine. 2 × 126.5		Water.		Sulphurous Acid. 63 90 (SO_2)		Sulphuric Acid.		Hydriodic Acid.

126.5 parts are equivalent to . . 31.95 parts.

1000 Cc. $\frac{N}{10}$ V. S. containing 12.65 Gm. Iodine are equivalent to 3.195 Gm. of Sulphurous Oxide.

1 Cc. " " 0.01265 Gm. Iodine is equivalent to 0.003195 Gm. of Sulphurous Oxide.

(*c*) *Estimation of Hyposulphites* (*Thiosulphates*).

The equation is as follows:—

$2I$	+	$2(Na_2S_2O_3.5H_2O)$	=	$2NaI$	+	$Na_2S_4O_6$	+	$10H_2O$
Iodine. 2 × 126.5		Sodium Hyposulphite. 2 × 247.64		Sodium Iodine.		Sodium Tetrathionate.		Water.

126.5 parts are equivalent to 247.64 parts.

1000 Cc. $\frac{N}{10}$ V. S. containing 12.65 Gm. Iodine are equivalent to 24.764 Gm. of Sodium Hyposulphite.

1 Cc. " " 0.01265 Gm. Iodine is equivalent to 0.024764 Gm. of Sodium Hyposulphite.

(9) Decinormal Sodium Hyposulphite Volumetric Solution.

$Na_2S_2O_3 + 5H_2O = 247.64$. 24.764 Gm. in 1 Liter.

This solution is standardized by means of decinormal iodine V. S.

"Dissolve 30 Gm. of selected crystals of sodium hyposulphite (sodium thiosulphate) in enough water to make, at or near 15° C. (59° F.), 1100 Cc. Of this solution transfer 10 Cc. into a flask, add a few drops of starch T. S., and then gradually add, from a burette, decinormal iodine V. S., in small portions at a time, shaking the flask after each addition, and regulating the flow to drops toward the end of the operation. As soon as the color produced by the influx of the iodine solution no longer disappears on shaking, but is not deeper than very pale blue, note the number of Cc. of the iodine solution consumed. Then dilute the sodium hyposulphite solution so that equal volumes of it and of decinormal iodine V. S. will exactly correspond to each other under the conditions mentioned above.

Example.—Assuming that 10 Cc. of the stronger sodium hyposulphite solution first prepared had required 10.7 Cc. of decinormal iodine V. S. to produce a faint reaction with starch, the hyposulphite solution must be diluted in the proportion of 10 Cc. to 10.7 Cc., or 1000 Cc. to 1070 Cc.

After the solution is thus diluted, a new trial should be made in the manner above described, in which 50 Cc. of the decinormal sodium hyposulphite V. S. should require exactly 50 Cc. of decinormal iodine V. S. to produce a faint reaction with starch. If necessary, a new adjustment should then be made to render the correspondence perfect.

Keep the solution in small, dark amber-colored, glass-stoppered bottles, carefully protected from dust.

Note.—When this solution is to be used, fill a burette with it, place the liquid to be tested either for the free iodine it already contains, or for that which it liberates from an excess of potassium iodide added to it, into a flask, and gradually add small portions of the solution from the burette, shaking after each addition, and regulating the flow to drops towards the end of the operation, until the brown color of the iodine has nearly disappeared. Now add a few drops of starch T. S., which will produce a blue color, and then continue to add the hyposulphite solution in drops until the blue tint is exactly discharged." (U. S. P.)

One Cubic Centimeter of Decinormal Sodium Hyposulphite V. S. is the equivalent of:

	Gramme.
Sodium Hyposulphite (Thiosulphate), $Na_2S_2O_3+5H_2O$	0.024764
Bromine, Br	0.007976
Chlorine, Cl	0.003537
Iodine, I	0.012653
Iron, Fe, in ferric salts,	0.005588

(*a*) *Estimation of Free Iodine.*

A quantity of Iodine is weighed off, and by aid of potassium iodide dissolved in water. Then the hyposulphite solution is added, under constant stirring, until the solution has paled to a yellowish tint. A little starch paste is now added, and the addition of the hyposulphite continued in drops until the blue color just disappears.

Then according to the equation:—

$2(Na_2S_2O_3.5H_2O)$	+	$2I$	=	$2NaI$	+	$Na_2S_4O_6$	+	$10H_2O$
Sodium Hyposulphite.		Iodine.		Sodium Iodide.		Sodium Tetrathionate.		Water.
2 × 247.64		2 × 126.5						

247.64 parts are equivalent to 126.5 parts.

1000 Cc. $\frac{N}{10}$ V. S. containing 24.764 Gm. Sodium Hyposulphite are equivalent to 12.65 Gm. Iodine.

1 Cc. " " " 0.024764 Gm. Sodium Hyposulphite is equivalent to 0.01265 Gm. Iodine.

(*b*) *Estimation of Free Chlorine or Bromine.*

This process is adapted to all substances containing free Chlorine or Bromine. (See also, Aqua Chlori, page 223.) The substance is weighed off and added to water containing a slight excess of potassium iodide, whereupon either the chlorine or bromine liberates an *equivalent* quantity of iodine from the potassium iodide, which in turn is estimated by means of the hyposulphite solution as directed above:—

$2Cl$	+	$2KI$	=	$2KCl$	+	$2I$	
Chlorine.		Potassium Iodide.		Potassium Chloride.		Iodine.	
2 × 35.37						2 × 126.5	
35.37	parts of Cl are equivalent to					126.5	parts of I.
3.537	" " " " "					12.65	" "
0.003537	" " " " "					0.01265	" "

Since 1 Cc. of decinormal Sodium Hyposulphite solution (0.024764 Gm. of the salt) is equivalent to 0.01265 Gm. of iodine, and as this is equivalent to 0.003537 Gm. of Chlorine, hence 1 Cc. of decinormal sodium hyposulphite solution is equivalent to 0.003537 Gm. of Chlorine.

On this same principle 1 Cc. of decinormal Sodium Hyposulphite solution is equivalent to 0.007976 Gm. of bromine, for—

$2Br$	+	$2KI$	=	$2KBr$	+	$2I$	
Bromine.		Potassium Iodide.		Potassium Bromide.		Iodine.	
2 × 79.76						2 × 126.5	
79.76	parts of Br. are equivalent to					126.5	parts of Iodine.
0.007976	" " " "					0.01265	" "

(*c*) *Estimation of Iron in Ferric Salts.*

A suitable quantity of the iron salt or solution is weighed off and added to water contained in a glass stoppered bottle. To this is added some hydrochloric acid and an excess of potassium iodide (which must be absolutely free from iodate). The mixture is kept for half an hour at a temperature of 40° C., then cooled, and mixed with a few drops of starch T. S. Decinormal solution

of sodium hyposulphite is then run in till the blue color of the solution is discharged.

The ferric chloride causes the liberation of an amount of iodine equivalent to the amount of metallic iron present. The ferric is reduced to ferrous chloride. The hydrochloric acid added serves to prevent the solution of the iodine by the excess of potassium iodide present. The reaction is as follows:—

Fe_2Cl_6	+	$2KI$	=	$2FeCl_2$	+	$2KCl$	+	$2I$
Ferric Chloride. 2×55.8 (Fe)		Potassium Iodide.		Ferrous Chloride.		Potassium Chloride.		Iodine. 2×126.5

55.8 parts of Metallic Iron are equivalent to . . . . . 126.5 parts of Iodine.
0.00558 " " " " " " . . . . . 0.01265 " "

Since, according to the equation *c* (page 433), 1 Cc. of decinormal hyposulphite solution (containing 0.02476 Gm. of the salt) is equivalent to 1 Cc. of decinormal iodine solution (0.01265 Gm.), and as this is equivalent to 0.00558 Gm. metallic iron, hence 1 Cc. of the hyposulphite solution is equivalent to 0.00558 Gm. of metallic iron.

(10) DECINORMAL POTASSIUM DICHROMATE VOLUMETRIC SOLUTION.

$K_2Cr_2O_7 = 293.78.$ 4.896 Gm.* in 1 Liter.

Dissolve 4.896 Gm.* of pure potassium dichromate (see below) in enough water to make, at or near 15° C. (59° F.), exactly 1000 Cc.

If the potassium bichromate is pure,† it is directly dissolved as above indicated. If not, it may be standardized by making an estimation upon 0.5 Gm. of pure iron (piano) wire, dissolved in dilute sulphuric acid, as described on page 437 equation *a*.

When used with phenolphtalein as indicator, to neutralize alkalies, the volumetric solution of potassium dichromate is decinormal when it contains 14.689 Gm. in 1 liter. It is then the exact equivalent of any decinormal acid, corresponding to the amounts of alkalies quoted, for instance, under Decinormal Oxalic Acid V. S.

The dichromate is equivalent to two molecules of hydrochloric acid; thus:—

$$K_2Cr_2O_7 + 2HCl = 2KCl + 2CrO_3 + H_2O$$

Hence 1 molecule of the acid is equivalent to ½ molecule of the bichromate ($K_2C_2O_7 = 146.89$). The decinormal solution, therefore, is made to contain but 14.689 Gm.

When used as an oxidizing agent to convert ferrous into ferric salts, or to liberate iodine from potassium iodide, the solution just

* "Generally rounded off to 4.9 Gm., when a delicate balance and exact weights are not available."

† The Pharmacopœia specifies that *Pure Potassium Dichromate* for use in volumetric analysis, besides responding to the tests given in the text of the Pharmacopœia (under *Potassii Bichromas*), must conform to the following tests. In a solution of 0.5 Gm. of the salt in 10 Cc. of water rendered acid by 0.5 Cc. of nitric acid, no visible change should be produced either by barium chloride T. S. (absence of *sulphate*), or by silver nitrate T. S. (absence of *chloride*). In a mixture of 10 Cc. of the aqueous solution (1 in 20) with 1 Cc. of ammonia water, no precipitate should be produced by ammonium oxalate T. S. (absence of *calcium*).

mentioned (containing 14.689 Gm. in 1 liter) has the effect of a $\frac{3N}{10}$ volumetric solution, and a solution of one-third of this strength, containing 4.896 Gm. in 1 liter, has the value of a decinormal solution.

Upon heating 1 molecule of the bichromate with an acid (H_2SO_4), *three atoms* of nascent oxygen are liberated. Thus:—

$$K_2Cr_2O_7 + 4H_2SO_4 = K_2SO_4 + Cr_2(SO_4)_3 + 4H_2O + O_3$$

These *three atoms* of oxygen possess the power to convert *six atoms* of iron from the *ferrous* to the *ferric* state, according to the equation—

$$6FeO + O_3 = 3Fe_2O_3$$

Therefore each molecule of the dichromate, yielding *three* atoms of oxygen, is equivalent to *six atoms* of hydrogen. Hence, according to the principle expressed on page 413, we take $\frac{1}{6}$ of the molecular weight of a decinormal solution of the bichromate ($\frac{1}{6}$ of 29.378 = 4.896), thereby reducing it to the valency corresponding to one atom of replaceable hydrogen.

As a decinormal solution, it is the equivalent of an equal volume of decinormal potassium permanganate V. S., or, in the case of iodine liberated from potassium iodide, it is the equivalent of an equal volume of decinormal sodium hyposulphite V. S. For titrating iron in *ferrous* compounds, it is used in the following manner: Introduce the aqueous solution of the ferrous salt into a flask and, if it is not already acid, render it so with sulphuric acid. Now add, gradually, decinormal potassium dichromate V. S. from a burette, until a drop taken out upon a white surface no longer shows a blue color with a drop of freshly prepared potassium ferricyanide T. S.

Decinormal potassium dichromate V. S. may also be used, in conjunction with potassium iodide (from which it liberates iodine) and sulphuric acid, for adjusting the titer of sodium hyposulphite (thiosulphate) V. S. and, by its means, that of the iodine V. S.

One Cubic Centimeter of Decinormal Potassium Dichromate V. S. is the equivalent of:

	Gramme.
Potassium Dichromate, $K_2Cr_2O_7$	0.0048963
Iron, in ferrous compounds,	0.005588
Ferrous Carbonate, $FeCO_3$	0.011573
Ferrous Sulphate, anhydrous, $FeSO_4$	0.015170
Ferrous Sulphate, crystallized, $FeSO_4 + 7H_2O$	0.027742
Ferrous Sulphate, dried, $2FeSO_4 + 2H_2O$	0.017864
Potassium Hydrate, KOH	0.001866
Sodium Hyposulphite (Thiosulphate), $Na_2S_2O_3 + 5H_2O$	0.024764

Estimation of Metallic Iron and Ferrous Salts.

(*a*) *Metallic Iron.*—Any definite amount of iron (about 0.5 Gm.) is weighed off (if it is intended for standardizing, piano wire should be selected), then dissolved by the aid of heat in dilute sul-

phuric acid, in a flask with a close fitting cork, through which passes a short glass tube, which is fitted into a rubber tube closed at the other extremity, and in the side of which an incision is made which will allow steam and hydrogen gas to pass out, but will prevent the air from passing in. When the iron is dissolved, the solution is titrated directly in the flask, or rinsed out into a beaker. The titration is carried out as directed in the preceding paragraph. The failure of the ferricyanide solution to produce a blue color with the resulting mixture indicates that the oxidation of the *ferrous* to the *ferric* condition is complete.

The first half of the operation embraces the solution of the metallic iron, yielding ferrous sulphate, the operation being performed under conditions which obviate any possible formation of ferric salts resulting from contact with air:—

$$\underset{6 \times 55.88}{6Fe} + 6H_2SO_4 = \underset{6 \times 151.7}{6FeSO_4} + 3H_2$$

The following reaction illustrates the oxidation of the *ferrous* to *ferric* salt:—

$$\underset{\substack{\text{Ferrous}\\\text{Sulphate.}\\910.2}}{6FeSO_4} + \underset{\substack{\text{Potassium}\\\text{Dichromate.}\\293.78}}{K_2Cr_2O_7} + \underset{\substack{\text{Sulphuric}\\\text{Acid.}}}{7H_2SO_4} = \underset{\substack{\text{Ferric}\\\text{Sulphate.}}}{3Fe_2(SO_4)_3} + \underset{\substack{\text{Potassium}\\\text{Sulphate.}}}{K_2SO_4} + \underset{\text{Chromium Sulphate.}}{Cr_2(SO_4)_3} + \underset{\text{Water.}}{7H_2O}$$

Hence—

$$\underset{\substack{293.78\\48.96 \text{ parts}}}{K_2Cr_2O_7} = \underset{\substack{6 \times 151.7\\151.7 \text{ parts}}}{6FeSO_4} = \underset{\substack{6 \times 55.88\\55.88 \text{ parts.}}}{6Fe}$$

1000 Cc. $\frac{N}{10}$ V. S. containing 4.896 Gm. dichromate = 15.17 Gm. ferrous sulphate = 5.588 Gm. metallic iron.

1 Cc. " " 0.004896 Gm. dichromate = 0.01517 Gm. ferrous sulphate = 0.005588 metallic iron.

(*b*) *Crystallized Ferrous Sulphate.*

The weighed amount of salt is dissolved in water containing dilute sulphuric acid and titrated as directed above.

$$\underset{293.78}{K_2Cr_2O_7} + \underset{6 \times 277.42}{6\,FeSO_4.7H_2O} + 7H_2SO_4 = 3Fe_2(SO_4)_3 + K_2SO_4 + Cr_2(SO_4)_3 + 14H_2O$$

293.78 parts of $K_2Cr_2O_7$ are necessary for the oxidation of 6 × 277.42 parts of ferrous sulphate.
48.96 " " " " " " " 277.42 " " " "

1000 Cc. $\frac{N}{10}$ V. S. containing 0.004896 Gm. of $K_2Cr_2O_7$ are necessary for the oxidation of 0.027742 Gm. of crystallized ferrous sulphate.

(*c*) *Ferri Carbonas Saccharatus.*

$$\underset{293.78}{K_2Cr_2O_7} + \underset{6 \times 115.73}{6FeCO_3} + 7H_2SO_4 = 3Fe_2(SO_4)_3 + K_2SO_4 + Cr_2(SO_4)_3 + 7H_2O$$

293.78 parts of $K_2Cr_2O_8$ are necessary for the oxidation of 6 × 115.73 parts of ferrous carbonate.
48.96 " " " " " " " 115.73 " " " "

Then 1 Cc. of the dichromate solution (or 0.004896 Gm. of the salt) is equivalent to 0.011573 Gm. of ferrous carbonate.

(d) *Potassium Iodide and Sodium Hyposulphite.*

$$\underset{293.78}{K_2Cr_2O_7} + 6KI + 7H_2SO_4 = 4K_2SO_4 + Cr_2(SO_4)_3 + \underset{6 \times 126.6}{3I_2}$$

48.96 parts are capable of liberating . . . . 126.6 parts

1000 Cc. containing 4.896 Gm. of $\frac{N}{10}$ Dichromate V. S. are equivalent to 12.66 Gm. of Iodine.

1 Cc. " 0.004896 " " " " is equivalent to 0.01266 Gm. of Iodine, or 0.02476 Gm. of Sodium Hyposulphite (1 Cc.).

(11) Decinormal Potassium Permanganate Volumetric Solution.

$2KMnO_4 = 315.34.$ 3.1534 Gm.* in 1 Liter.

For the estimation of Iron, this solution is far more satisfactory than the decinormal dichromate solution, since the end point of the reaction is readily distinguished, and does not require the use of reagents, as is the case in the latter.

Two molecules of potassium permanganate ($2KMnO_4$) in oxidation give off five atoms of oxygen, which oxidizes the ferr*ous* of 10 atoms of metallic iron to ferr*ic* condition, thus:—

$$\underset{\substack{\text{Potassium} \\ \text{Permanganate.} \\ 315.34}}{2KMnO_4} + \underset{\substack{\text{Ferrous} \\ \text{Oxide.}}}{10FeO} = \underset{\substack{\text{Ferric} \\ \text{Oxide.}}}{5Fe_2O_3} + \underset{\substack{\text{Manganous} \\ \text{Oxide.}}}{2MnO} + \underset{\substack{\text{Potassium} \\ \text{Oxide.}}}{K_2O}$$

$\frac{2}{10}$ molecule $KMnO_4$ yield $\frac{5}{10}$ molecule of oxygen, or $\frac{1}{5}$ molecule $KMnO_4$ yields $\frac{1}{2}$ molecule of oxygen.

But $\frac{1}{2}$ molecule of oxygen = 1 atom of hydrogen.

Hence $\frac{1}{5}$ of the molecular weight of $KMnO_4$ or $\frac{1}{10}$ of the molecular weight of $2KMnO_4$ is equivalent to one atom of hydrogen; hence the normal solution of potassium permanganate should contain $\frac{315.34}{10}$ ($2KMnO_4$) = 31.534 Gm. of salt.

If the *normal* solution contains 31.534 Gm., then the *decinormal* solution must contain $\frac{1}{10}$th of this, or 3.1534 Gm. in the Liter.

The next step is to prepare the solution. This cannot be done directly, by weighing out 3.1534 Gm. of the salt, partly because the salt is but rarely absolutely pure, and partly because any oxidizable matters in the water used for solution would consume some of the salt. The adjustment must, therefore, be made indirectly by means of either Oxalic Acid or Iron. In order to do this, a solution of approximate strength is first prepared.

The Pharmacopœia gives the following directions:—

"I. Place 3.5 Gm. of pure, crystallized potassium permanganate in a flask, add 1000 Cc. of boiling water, and boil until the crystals are dissolved. Close the flask, and set it aside for two days, so that any suspended matters may deposit. This is the *stronger solution*. Prepare another, *weaker solution*, in the same manner, using 6.6 Gm. of the salt and 2200 Cc. of water, and set this also aside for two days. After the lapse of this time, pour off the clear

* This quantity is never directly weighed, but adjusted either by Oxalic Acid or by Iron; in calculations it is often abbreviated.

portion of each solution into separate vessels provided with glass stoppers, and then proceed to test each separately."

This solution is standardized by means of oxalic acid, the decinormal volumetric solution being employed. The reaction proceeds thus:—

$$\underset{\text{Potassium Permanganate. 315.3}}{2KMnO_4} + \underset{\text{Oxalic Acid. 628.5}}{5(H_2C_2O_4 + 2H_2O)} + \underset{\text{Sulphuric Acid.}}{3H_2SO_4} = \underset{\text{Potassium Sulphate.}}{K_2SO_4} + \underset{\text{Manganese Sulphate.}}{2MnSO_4} + \underset{\text{Carbonic Acid Gas.}}{10CO_2} + \underset{\text{Water.}}{8H_2O}$$

1000 Cc. of the decinormal V. S. should contain 3.153 Gm. permanganate = 6.285 Gm. oxalic acid.

1 Cc. of the decinormal V. S. should contain 0.003153 Gm. permanganate = 0.006285 Gm. oxalic acid.

Hence the 10 Cc. of the decinormal acid solution containing 0.06285 Gm. of oxalic acid will be equivalent to 0.03153 Gm. of potassium permanganate. Sulphuric acid is employed in all reactions with permanganate, in order to dissolve the separated brown manganic hydrate and to convert it into manganic sulphate, which does not impart a color to the liquid. The presence of the suspended brown precipitate of manganic hydrate would render it next to impossible to recognize the end of the reaction.

"Introduce into a flask 10 Cc. of decinormal oxalic acid V. S., add 1 Cc. of pure, concentrated sulphuric acid, and, before this mixture cools, gradually add from a burette small quantities of the weaker permanganate solution, shaking the flask after each addition and reducing the flow to drops toward the end of the operation. When the last drop of the permanganate solution added is no longer decolorized but imparts a pinkish tint to the liquid, note the number of Cc. consumed. In the same manner ascertain the titer of the stronger solution, and likewise note down the number of Cc. of the latter consumed. Finally mix the two solutions in such proportions that 50 Cc. of the mixture will exactly correspond to an equal volume of decinormal oxalic acid V. S.

Note.—To obtain the accurate proportions for mixing the two solutions, deduct 10 from the number of Cc. of the weaker solution required to decompose 10 Cc. of decinormal oxalic acid V. S. With this difference multiply the number of Cc. of the stronger solution required for the same purpose. The product shows the number of Cc. of the *stronger solution* needed for the mixture.

Next deduct the number of Cc. of the stronger solution required to decompose 10 Cc. of decinormal oxalic acid V. S. from 10, and with the difference multiply the number of Cc. of the weaker solution required for the same purpose. The product shows the number of Cc. of the *weaker solution* needed for the mixture.

Or, designating by S the number of Cc. of the stronger solution and by W the number of Cc. of the weaker solution required to

decompose 10 Cc. of decinormal oxalic acid V. S., the following formula will give the proportions in which the solutions must be mixed:—

Stronger Solution.		Weaker Solution.
(W—10)S	+	(10—S)W

Example.—Assuming that 9 Cc. of the stronger (S) and 10.5 of the weaker (W) solution had been required, then substituting these values in the above given formula, we obtain:—

Stronger Solution.		Weaker Solution.
(10.5—10)9	+	(10—9) 10.5
or, 4.5.	+	or, 10.5

making 15 Cc. of final solution.

The bulk of the two solutions is now mixed in the same proportion 450 Cc. of the stronger and 1050 Cc. of the weaker, or 900 Cc. of the stronger and 2100 Cc. of the weaker solution.

After the mixture is thus prepared, a new trial should be made, when 10 Cc. of the solution should exactly decompose 10 "Cc. of the decinormal oxalic acid V. S. If necessary, a new adjustment should be made to render the correspondence perfect.

This solution should be kept in small, dark amber-colored and glass-stoppered bottles (or in bottles provided with tubes, especially designed for the purpose). Thus prepared, this solution will hold its titer for months; yet it should be tested occasionally, and, when it is found reduced, the liquid should be brought back to normal strength by the addition of such an amount of the stronger solution as may be determined in the manner above described.

II. When potassium permanganate V.S. is to be prepared for immediate use, this may be done in the following manner. Dissolve 3.5 Gm. of pure, crystallized potassium permanganate in 1000 Cc. of pure water, recently boiled and cooled. Introduce 10 Cc. of decinormal oxalic acid V. S. into a beaker, add 1 Cc. of pure, concentrated sulphuric acid, and proceed as directed above for the weaker permanganate solution. Note the number of Cc. of the solution consumed, and then dilute the remainder with pure water recently boiled and cooled, until 50 Cc. will exactly correspond to 50 Cc. of decinormal oxalic acid V. S.

Example.—Assuming that 9.1 Cc. of the Permanganate solution first prepared had been required to produce a permanent pink tint, then every 9.1 Cc. of the solution must be diluted to 10 Cc., or the whole of the remaining solution in the same proportion. A new trial should then be made to verify the agreement.

Note.—Potassium permanganate V. S. thus prepared is liable to deteriorate more readily and quickly than that prepared by the method first given (under I.). It cannot be safely trusted without verification, each time it is to be used."

One Cubic Centimeter of Decinormal Potassium Permanganate V. S. is the equivalent of:

	Gramme.
Potassium Permanganate, $KMnO_4$	0.0031534
Barium Dioxide, BaO_2	0.008441
Calcium Hypophosphite, $Ca(PH_2O_2)_2$	0.0021209
Ferric Hypophosphite, $Fe_2(PH_2O_2)_6$	0.0020877
Iron, in ferrous compounds, Fe	0.005588
Ferrous Carbonate, $FeCO_3$	0.011573
Ferrous Oxide, FeO	0.007195
Ferrous Sulphate, anhydrous, $FeSO_4$	0.015170
Ferrous Sulphate, crystals, $FeSO_4 + 7H_2O$	0 027742
Ferrous Sulphate, dried, $2FeSO_4 + 3H_2O$	0.017864
Hydrogen Dioxide, H_2O_2	0.001696
Hypophosphorous Acid, HPH_2O_2	0.001647
Oxalic Acid, crystallized, $H_2C_2O_4 + 2H_2O_6$	0.906285
Oxygen, O	0.000798
Potassium Hypophosphite, KPH_2O_2	0.002598
Sodium Hypophosphite, $NaPH_2O_2 + H_2O$	0.002646

(*a*) *Estimation of Hydrogen Dioxide.*

A weighed quantity of the solution, diluted with water, is rendered decidedly acid with sulphuric acid, and decinormal permanganate solution is run in until the liquid retains a faint pink tint after being stirred.

The reaction proceeds thus:—

$$\underset{315.2}{2KMnO_4} + \underset{169.6}{5H_2O_2} + 3H_2SO_4 = 5O_2 + 8H_2O + K_2SO_4 + 2MnSO_4$$

1000 Cc. of $\frac{N}{10}$ V. S. containing 3.152 Gm. of permanganate correspond to 1.696 Gm. of Hydrogen Peroxide.

1 Cc. " " 0.003152 Gm. of permanganate correspond to 0.001696 Gm. of Hydrogen Peroxide.

Barium Dioxide, is estimated in the same manner, its oxygen being, however, first converted into hydrogen peroxide by reaction with phosphoric acid, thus:—

$$\underset{\substack{\text{Barium Dioxide.}\\3\times 168.8}}{3BaO_2} + \underset{\text{Phosphoric Acid.}}{2H_3PO_4} = \underset{\text{Barium Phosphate.}}{Ba_3(PO_4)_2} + \underset{\substack{\text{Hydrogen Peroxide.}\\3\times 33.92}}{3H_2O_2}$$

Each 506.4 parts of Barium Dioxide yield theoretically 101.76 parts of absolute hydrogen peroxide.

(*b*) *Estimation of Ferrous Sulphate.*

The reaction proceeds as follows:

$$\underset{315.3}{2KMnO_4} + \underset{2774.2\ (558.8\ Fe.)}{10FeSO_4 + 7H_2O} + 8H_2SO_4 = 5(Fe_2(SO_4)_3) + K_2SO_4 + 2MnSO_4 + 15H_2O$$

That is, 315.3 parts of $2KMnO_4$ correspond to 558.8 parts of Fe or to 2774.2 parts of $FeSO_4+7H_2O$.

1000 Cc. of the decinormal permanganate (containing 3.153 Gm. of the salt) correspond to 5.588 Gm. of metallic iron, or to 27.742 Gm. of crystallized ferrous sulphate. Hence, 1 Cc. of the decinormal permanganate (containing 0.003153 Gm. of the salt) corresponds to 0.027742 Gm. of crystallized ferrous sulphate.

(c) *Estimation of Metallic Iron.*

The metallic iron is dissolved in a flask containing dilute sulphuric acid under the same precautions, to avoid oxidation, as directed under potassium bichromate (page 437, *a*). The resulting solution contains the iron as ferrous sulphate. :—

$$\underset{558.8}{5Fe_2} + 10H_2SO_4 = \underset{1517}{10FeSO_4} + 5H_2$$

The decinormal permanganate solution is now run in, until the solution, after stirring, retains a faint pink color.

$$\underset{315.3}{2KMnO_4} + \underset{1517\ (558.8\ Fe)}{10FeSO_4} + 8H_2SO_4 = 5(Fe_2(SO_4)_3) + K_2SO_4 + 2MnSO_4 + 8H_2O$$

1 Cc. of the decinormal permanganate (containing 0.003153 Gm. of the salt) corresponds to 0.01517 Gm. of anhydrous ferrous sulphate or to 0.005588 Gm. of metallic iron.

(d) *Estimation of Ferrous Carbonate.*

A weighed amount of ferrous carbonate is dissolved in dilute sulphuric acid and titrated as directed in the U. S. P.

The reaction is as follows:—

$$\underset{1157.3\ (558.8\ Fe).}{10FeCO_3} + 10H_2SO_4 = \underset{1517}{10FeSO_4} + 10CO_2 + 10H_2O$$

$$\underset{315.3}{2KMnO_4} + \underset{1517\ (558.8\ Fe).}{10FeSO_4} + 8H_2SO_4 = 5(Fe_2(SO_4)_3) + 2MnSO_4 + K_2SO_4 + 8H_2O.$$

That is, 315.3 parts of permanganate correspond to 558.8 parts of metallic iron, which in turn corresponds to 1157.3 Gm of ferrous carbonate. 1 Cc. of decinormal potassium permanganate solution (containing 0.003153 Gm. of the salt) corresponds to 0.005589 Gm. of metallic iron, or to 0.011573 Gm. of ferrous carbonate.

(e) *Estimation of Hypophosphorous Acid, Free and in Hypophosphites.*

The reaction occurring in these titrations is as follows:—

$$\underset{2\times 315.3}{2K_2Mn_2O_8} + \underset{329.4}{5H_3PO_2} + 6H_2SO_4 = 2K_2SO_4 + 4MnSO_4 + 6H_2O + 5H_3PO_4.$$

315.3 parts of Permanganate correspond to 164.7 parts of Hypophosphorous acid.

1 Cc. of permanganate solution (containing 0.003153 Gm. of potassium permanganate) corresponds to 0.001647 Gm. of hypophosphorous acid or to a corresponding amount of any hypophosphite.

(12) Decinormal Bromine Volumetric Solution.

[Koppeschaar's Solution.]

Br = 79.76 7.976 Gm. in 1 Liter.
($NaBrO_3$ = 150.64.—NaBr = 102.76.)
($KBrO_3$ = 166.67.—KBr = 118.79.)

"Dissolve 3 Gm. of sodium bromate and 50 Gm. of sodium

bromide (or 3.2 Gm. of potassium bromate and 50 Gm. of potassium bromide) in enough water to make, at or near 15° C. (59° F.), 900 Cc. Of this solution transfer 20 Cc., by means of a pipette, into a bottle having a capacity of about 250 Cc., provided with a glass stopper; add 75 Cc. of water, next 5 Cc. of pure hydrochloric acid, and immediately insert the stopper. Shake the bottle a few times, then remove the stopper just sufficiently to quickly introduce 5 Cc. of potassium iodide T. S., taking care that no bromine vapor escape, and immediately stopper the bottle. Agitate the bottle thoroughly, remove the stopper and rinse it and the neck of the bottle with a little water so that the washings flow into the bottle, and then add from a burette decinormal sodium hyposulphite V. S. until the iodine tint is exactly discharged, using toward the end a few drops of starch T. S. as indicator. Note the number of Cc. of the sodium hyposulphite V. S. thus consumed, and then dilute the bromine solution so that equal volumes of it and of decinormal sodium hyposulphite V. S. will exactly correspond to each other under the conditions mentioned above.

Example.—Assuming that the 20 Cc. of the bromine solution have required 25.2 Cc. of the hyposulphite to completely discharge the iodine tint, the bromine solution must be diluted in the proportion of 20 to 25.2. Thus, if 850 Cc. of it are remaining, they must be diluted with water to measure 1071 Cc.

After the solution is thus diluted, a new trial should be made in the manner above described, in which 25 Cc. of the decinormal sodium hyposulphite V. S. should exactly discharge the tint of the iodine liberated by the bromine set free from the 25 Cc. of bromine solution.

Keep the solution in dark amber-colored, glass-stoppered bottles."

One Cubic Centimeter of Decinormal Bromine Solution V. S. is the equivalent of:

	Gramme.
Bromine, Br	0.007976
Carbolic Acid, C_6H_5OH	0.001563

On mixing potassium or sodium bromate with their respective bromides in presence of hydrochloric or sulphuric acid and water, bromine is set free according to the following reaction.

$$KBrO_3 + 5KBr + 6HCl = 6KCl + 3H_2O + 3Br_2$$

In order to ascertain the normal amount of bromine present, for the purpose of standardization, potassium iodide is introduced, whereby a quantity of iodine exactly equivalent to the free bromine present is liberated. Upon estimating the amount of the liberated iodine with sodium hyposulphite, the result represents the equivalent amount of bromine:—

$$\underset{2\times 79.76}{Br_2} = \underset{2\times 126.6}{I_2} = \underset{2\times 247.64}{2(Na_2S_2O_3,5H_2O)}$$

$$79.76 \text{ parts} = 126.6 \text{ parts} = 247.64 \text{ parts.}$$

That is, 1 Cc. of decinormal hyposulphite solution (containing 0.024764 Gm. of sodium hyposulphite) corresponds to 0.01266 Gm. of Iodine, which in turn represents 0.007976 of Bromine.

This solution is employed in the valuation of carbolic acid, depending, for its action, upon the formation of tribrom-phenol, in which an excess of the bromine solution is added to a weighed amount of carbolic acid dissolved in water; the excess of bromine which has *not* combined with the phenol, is estimated as explained above; that is, the equivalent amount of iodine liberated from potassium iodide added is determined by sodium hyposulphite, the difference being the amount of combined bromine. The reaction proceeds thus:—

$$\underset{\text{Bromine.}}{6Br} + \underset{\text{Phenol.}}{C_6H_5OH} = \underset{\text{Tribrom-phenol.}}{C_6H_2Br_3OH} + \underset{\text{Hydrobromic Acid.}}{3HBr}$$

79.76 parts of bromine correspond to 15.63 parts of phenol.

Hence

1 Cc. of the bromine solution (containing 0.007976 Gm. of bromine) corresponds to 0.001563 Gm. of phenol.

PART V.

CHAPTER XXXVIII.

URINE AND ITS ANALYSIS.

SECRETION OF URINE.

While our knowledge regarding the physiology of the secretion and subsequent excretion of urine is fairly accurate and advanced, there still remain a number of points concerning which there is considerable doubt. Enough, however, is known to state with a considerable degree of certainty that the act of secretion is partly physical and partly vital. The anatomical theory, or Bowman's theory, takes into consideration primarily the anatomical structure of the kidneys (see Anatomy, Gray or Henle). This theory teaches that the epithelial cells lining the urinary tubules are the true secreting agents, and that the glomeruli simply act in the capacity of filters—that is, simply remove watery elements from the circulation. In other words, the epithelium secretes the constituents other than water, while the glomeruli separate the water, which in turn extracts the bodies found in the epithelial cells in its passage over them.

Opposed to this we find the purely physical theory of Ludwig, who bases his conclusions on the fact that there exist varying degrees of blood pressure in the circulation of the glomeruli, the process being in part a diffusion or osmosis and in part a mere filtration, not taking into account at all the presence of the tubular epithelium. The fact being admitted that the greatest blood pressure of the kidney is found in the Malpighian tuft, because of the resistance to the exit of the blood through the efferent vessel, it will then be readily understood that all the essentials for the act of diffusion are at hand. Depending upon this greater pressure in the Malpighian tufts, an exudation of water with perhaps a small quantity of salts occurs from these tufts, this water passing on into the convoluted tubules. The withdrawal of water from the blood by the above process leaves it in a concentrated condition, and as in its onward flow it reaches the capillary plexus of vessels surrounding the convoluted tubules it finds all essentials for osmosis: within the tubules the thin fluid already secreted, in the surrounding vessels the thickened blood, and between them the tubular wall, acting as a membrane. A part

of the thin fluid in the convoluted tubes passes into the blood, while from the latter such substances as urea and salts pass into the water of the tubules, the whole being an interchange of elements and the resulting liquid constituting urine. This theory meets with the following objections, viz.: It takes no account whatever of the epithelial cells which line the urinary tubules, and which it would be only reasonable to suppose must serve some purpose, for, indeed, we know that in other portions of the body such or similar cells are found which have secreting functions. It is also found that in certain renal diseases in which occurs destruction of the cells aforementioned, the gravest results follow,—namely, the non-elimination of urea and similar substances from the blood, this being attended or followed by the condition known as uræmia. Lastly, experiments have proved beyond a doubt the distinct selective power of this epithelium. The experiments are as follows: If into the blood of an animal a moderately concentrated solution of indigo-sulphate of sodium be injected, it will soon be followed by a blue coloration of the urine, and a blue color will be imparted to the epithelium of the convoluted tubules and the ascending limb of Henle's tubes, while in the Malpighian structures no such coloration is observed. Furthermore, if the spinal cord of an animal is divided, thus paralyzing the action of the glomeruli and preventing the secretion of liquid, it will still be found that in a short while after the injection of the same solution a blue coloration will appear in the epithelial cells as noted above. After a longer period these cells again become colorless, the blue matter having passed into the tubes, where, finding no water, it crystallizes. We are therefore enabled to deduce the following facts:—

First.—That the water, and possibly a small percentage of salts, are secreted by the glomeruli.

Second.—That the solids are eliminated by the epithelial cells of the tubules and that this function is a vital one.

COMPOSITION OF URINE.

Urine, as normally constituted, is the result of that retrograde tissue metamorphosis, constantly going on in the healthy body, plus the products of such foods, both solid and liquid, as are introduced into the body to sustain life.

NORMAL CONSTITUENTS.—(*Classification of Hoppe-Seyler.*)

1. *Urea and Related Substances.*
   Uric Acid, Allantoin, Oxalic Acid, Xanthin, Guanin, Creatinin, Thio-(Sulpho) cyanic Acid.
2. *Fatty and other Non-nitrogenous Substances.*
   Fatty Acids of the Series CnH_2NO_2, Oxalic, Lactic, Glycero-Phosphoric Acids, very small quantities of Sugar (*Brucke*).

3. *Aromatic Substances.*
   The Ethereal Sulphates of Phenol, Cresol, Pyrocatechin, Indoxyl and Skatoxyl, Hippuric Acid, Aromatic Oxy Acids.
4. *Other Organic Substances.*
   Pigments, Ferments, especially Pepsin, Mucus, and Humous Substances.
5. *Inorganic Salts.*
   Chlorides of Sodium and Potassium, Potassium Sulphate, Sodium, Calcium, and Magnesium Phosphates, Silicic Acid, Ammonium Compounds and Calcium Carbonate.
6. *Gases.*
   Nitrogen and Carbonic Acid.

AMOUNT OF URINARY CONSTITUENTS PASSED IN TWENTY-FOUR HOURS.—(*Parkes.*)

Constituents.	Body Weight, 66 Kilogrammes.	Per Kilogramme of Body Weight.
Water,	1500.00 Gm.	23.000 Gm.
Total solids,	72.00 "	1.100 "
Urea,	33.18 "	0.500 "
Uric acid,	0.55 "	0.008 "
Hippuric acid,	0.40 "	0.006 "
Creatinin,	0.91 "	0.014 "
Pigment and other organic matters,	10.00 "	0.151 "
Sulphuric acid,	2.01 "	0.030 "
Phosphoric acid,	3.16 "	0.048 "
Chlorine,	7-8.00 "	0.126 "
Ammonium,	0.77 "	
Potassium,	2.50 "	
Sodium,	11.09 "	
Calcium,	0.26 "	
Magnesium,	0.21 "	

PROPORTION BETWEEN WATER AND SOLIDS OF URINE.—(*Becquerel.*)

Water,	967 Grs.	Total solids, 33 Grs. in 1000.
Organic solids,	24.865 "	
Inorganic solids,	8.135 "	

COLLECTION OF URINE FOR ANALYSIS.

It is primarily essential to obtain a sample which represents, or is a portion of, the entire product of the kidneys for twenty-four hours. This becomes necessary, because at various times during the twenty-four hours the relative quantity of solid and fluid contents vary, so in order to obtain a sample which represents the average product, it must be obtained from the entire daily quantity passed. To guard against premature decomposition, care should be observed that the vessel is perfectly clean and dry. From a half- to a one-gallon glass receptacle can be employed, which should be corked tight after each addition of urine to prevent access of air, and should be kept in a cool place.

Albumin and sugar, unless habitually present, are most likely to be found after a meal and least likely in urine voided in the early morning.

Urine that is to be used for purely microscopical examination should be absolutely fresh and as concentrated as possible. Concentration may be obtained by abstaining partially from the ingestion of fluids for twenty-four hours prior to its voidance. Freshness is essential, as only a slight degree of ammoniacal decomposition suffices to render urine alkaline, thereby causing certain morphological elements, such as epithelial cells, casts, etc., which may be present, to enter into solution.

CHANGES OBSERVED IN URINE UPON STANDING.

These changes depend, in the main, upon four factors.

First.—Reaction when voided.

Second.—Degree of concentration when voided.

Third.—Temperature to which voided urine is exposed.

Fourth.—Accessibility to micro-organisms.

Normal urine of the usual acid reaction begins to show changes at an ordinary temperature in about three days after being voided. There is usually at first a precipitation of urates of an amorphous character, subsequently one of uric acid, and in many cases one of calcium oxalate. At higher temperature these changes occur much sooner. As a result of the presence of micro-organisms, after a variable time, usually four to five days, ammoniacal decomposition occurs, urea being transformed into carbonate of ammonium. The amorphous urates are converted into urate of ammonium, and in place of the uric acid crystals, the characteristic crystals of ammonio-magnesian phosphate are observed. Calcium phosphate is also deposited, often at the sides of the container. The growing alkalinity finally destroys the micro-organisms.

Conversely, another change often occurs in acid urine, known as acid fermentation, resulting in a precipitation of acid urates and uric acid, and causing the urine to assume a darker color. It is supposed that this change is due to an acetic or lactic acid fermentation, caused by the presence of mucus which acts as a ferment.

PHYSICAL AND CHEMICAL CHARACTERS OF URINE.

It will be found convenient to consider the physical and chemical characters of urine as follows:—

First.—Color.

Second.—Odor.

Third.—Transparency and Consistence.

Fourth.—Specific Gravity.

Fifth.—Chemical Reaction.

Sixth.—Quantity.

Seventh.—Amount of Solids.

COLOR.

Normal urine, owing to varying circumstances, all within range of perfect health, may vary in color, although in general terms we speak of it as being a pale-yellow or amber-hued liquid.

Pale, watery urine contains proportionately small amounts of coloring matter as well as chemical substances. It is either of a faint acid, neutral, or even slightly alkaline reaction, and is caused in the main by the introduction into the system of large quantities of liquids.

A dark-colored urine, conversely, is concentrated, and contains relatively large quantities of salts and pigment. In reaction it is usually decidedly acid. It may be caused by any condition which results in a diminution of the excretion of water by the kidneys, the excretion of solids and coloring matter remaining the same. It also occurs after prolonged vigorous exercise, after hearty ingestion of food, or when the sweat glands have been unduly active, or when fluids have been withheld. Pathologically, a much wider variation of color is observed, being due to either a diminution or an increase of the normal pigments or the presence of an abnormal one.

Very light-colored urine is observed in any condition causing polyuria, such as diabetes, etc. Or it occurs as a result of certain pathological changes in the kidney structure, notably in amyloid degeneration and in interstitial nephritis. Here it is caused by increase in the excretion of water and a diminution in the excretion of pigment and solids.

High-colored urine is often the result of high fevers, and is mainly due to a concentration of the urine, less often to the presence of uro-erythrine.

Red urine is always caused by the presence of abnormal pigments.

Dark brown urine is caused by the presence of met-hæmoglobin, which is derived from the hæmoglobin of the blood.

Very dark or black urine is observed in certain cases of melanotic cancer, particularly if the urine be allowed to stand.

Green urine is observed in jaundice and is the result of the presence of biliverdin. Urine containing much sugar sometimes presents a green hue.

Blue urine, due to the presence of indigo, is not uncommon in cases of cholera, typhus, etc.

Urine may assume various colors, due to the ingestion of certain drugs, notably santonin, which causes it to assume a peculiar yellow color.

Halliburton gives the following concise table of color variations of the urine, with their causes:—

Color.	Cause of Coloration.	Pathological Condition.
Nearly colorless.	Dilution, or diminution of normal pigments.	Nervous conditions; hydruria, diabetes insipidus, granular kidney.
Dark yellow to brown-red.	Increase of normal, or occurrence of pathological, pigments.	Acute febrile diseases.
Milky.	Fat-globules.	Chyluria.
	Pus-corpuscles.	Purulent diseases of the urinary tract.
Orange.	Excreted drugs.	Santonin, chrysophanic acid.
Red or reddish.	Unchanged hæmoglobin.	Hemorrhages, or hæmoglobinuria.
	Pigments in food (logwood, madder, bilberries, fuchsin).	
Brown to brown-black.	Hæmatin.	Small hemorrhages.
	Methæmoglobin.	Methæmoglobinuria.
	Melanin.	Melanotic sarcoma.
	Hydrochinon and catechol.	Carbolic-acid poisoning.
Greenish yellow, greenish brown, approaching black.	Bile-pigments.	Jaundice.
Dirty green or blue.	A dark-blue scum on surface, with a blue deposit, due to an excess of indigo-forming substances.	Cholera, typhus; seen especially when the urine is putrefying.
Brown-yellow to red-brown, becoming blood-red upon adding alkalies.	Substances which are introduced into the system with senna, rhubarb, and chelidonium.	

ODOR.

Normal freshly voided urine has a peculiar, characteristic odor, described as aromatic by some authors. It is due to the presence of small quantities of phenylic, damoluric and taurylic acids.

The intensity of the uric odor varies much in health, depending much upon the degree of concentration of the urine.

Urine upon long standing acquires a putrescent odor in which ammonium is easily recognized. Putrescent owing to the decomposition of mucus, and ammoniacal owing to the decomposion of urea into ammonium carbonate by micro-organisms.

Certain drugs when taken impart a characteristic odor to urine; thus the odor of copaiba, sandalwood oil, cubebs, garlic, etc., is

easily distinguishable in the urine of persons who have ingested such drugs.

Pathologically considered, the odor of urine often affords a clue to certain conditions. So in cystitis, in many cases we have an ammoniacal urine, or a putrid urine in suppurating conditions of the kidney or ureters.

TRANSPARENCE AND CONSISTENCE.

Normal urine when voided, is usually clear, and of an aqueous consistence. After standing it often becomes cloudy, owing to the formation of what is known as a mucous cloud; this is unchanged by heat, alkalies or mineral acids.

Pathologically various causes are responsible for cloudy urine, such as the separation of phosphates, urates, carbonates, or organic substances, such as, blood, pus, chyle, excessive quantities of mucus, etc.

Urates disappear upon the application of gentle heat.

Phosphates disappear upon the addition of a mineral acid.

If upon the application of heat or addition of an acid, the cloudiness becomes intensified, it is presumable that the cloudiness is due to the presence of earthy phosphates or albuminous cell elements such as pus, blood, etc., etc.

If upon addition of acetic acid the cloudiness remains unchanged or grows slightly, it is probable that the turbidity is caused by mucus or micro-organisms.

Pathologically urine may become dense and viscid so that it is difficult to drop from a vessel. Alkaline urine containing much mucus or pus, highly albuminous urine, or urine containing large quantities of sugar, all exhibit this tendency. Chylous or white urine, owing to the presence of free fat, is often very thick.

Jelly urine is the name applied to a rare condition in which the urine assumes a jelly-like consistence, and is the result of fibrinuria.

SPECIFIC GRAVITY.

The specific gravity of normal urine is about 1.020 for an average amount of 1500 Cc. (50 oz.), passed during 24 hours. Within the limits of health however, variations from this standard may occur. They depend mainly upon the quantity and character of the food, and the rapidity of tissue changes.

Nitrogenous foods are the cause of a slight increase in the specific gravity, owing to the fact that they furnish a higher relative amount of solids than liquids. Active muscular exercise causes rapid tissue waste, which furnishing an increased amount of solids to be excreted, raises the specific gravity.

Profuse diaphoresis, from any cause, brings about a concentration of the urine and a consequent rise of the specific gravity.

Conversely the ingestion of large quantities of water will result in a diminution of the specific gravity.

Pathologically we often find the specific gravity of urine either increased or diminished, observations always being based upon the entire quantity voided during 24 hours.

Bright's disease in its various forms, almost uniformly exhibits a tendency to lower the specific gravity. In the different forms of functional albuminuria the specific gravity is usually raised. A reduction in the specific gravity of a urine, without diminution of volume, in connection with a renal disorder, is always to be looked upon as suspicious, showing the inability of the kidneys to excrete the proper amount of solids. The condition known as uræmia may be the result of such non-activity.

Glycosuria almost uniformly causes a rise in the specific gravity, and any urine above 1.030 should always be examined for sugar.

The specific gravity may be determined in several ways, the instrument known as the urinometer being almost invariably used, the pyknometer, however, being more accurate.

CHEMICAL REACTION.

A specimen of normal urine, taken from the product of 24 hours, always shows an acid reaction. This acidity is not due to the presence of free acid, as was formerly taught, but is due to acid sodium phosphate NaH_2PO_4, which is derived from the basic sodium phosphate, Na_3PO_4 contained in the blood; the acids found in the urine, such as carbonic, uric, hippuric, and sulphuric, unite with a part of the sodium of the basic salt, changing it into an acid one.

The reaction of urine passed at different times of the day usually varies; thus, soon after meals, the acidity becomes less, and in from three to four hours after a meal, is at its lowest; indeed, in some rare instances, acidity may change into alkalinity. From this it can be seen that freshly voided urine, may, in reaction, be alkaline. It is, however, of importance to observe whether the alkalinity be due to fixed or volatile alkali. It often becomes necessary in practice to render urine alkaline, and this is accomplished by the ingestion of alkaline carbonates and bicarbonates, or the salts of vegetable acids, such as citric, etc.

Conversely, it may be desirable to render the urine acid, and this result may be attained by ingestion of acids, or saccharin, or by severe muscular exercise.

QUANTITY.

The average quantity of urine passed by a healthy individual during 24 hours is 1500 Cc. (50 oz.). This is, however, subject to considerable variation, such variation being entirely compatible with health. During any given day of 24 hours, most urine is

passed in the afternoon; least at night. Copious diaphoresis or diarrhœa diminish the quantity.

Imbibing large quantities of liquids, exercise (moderate), the use of diuretic drugs, and excess of atmospheric moisture are some of the causes that increase the quantity.

Pathologically the urine may be increased or diminished, or at times may become suppressed.

SOLIDS.

The quantity of solids found in normal urine, making deductions from a specimen of mixed urine, that is, urine passed during 24 hours, depends upon certain conditions, chief among which are—

(*a*) Weight of the individual,
(*b*) Diet,
(*c*) Age,
(*d*) Amount of bodily exercise,

and will be found to average about 61 Gms. for an individual weighing 145 pounds avoirdupois, 67 kilogrammes (subsisting on the ordinary diet), of from 20 to 40 years of age and having an ordinary daily amount of bodily exercise.

The following methods are employed to ascertain the amount of solids in a sample of urine.

Take a convenient quantity, say from 20 to 30 Cc., place it in a previously weighed porcelain capsule and evaporate slowly over a water bath. When evaporation is complete allow the residue to cool slowly and weigh. Repeat the operation until no further loss of weight results and note difference in weight between capsule with residue and empty capsule.

This method, while fairly accurate, is tedious, consuming much time; so in place of it we employ the method of Häser as follows—

Multiply the last two figures of the specific gravity (carried out to three decimals) by the co-efficient 2.33, the result being the number of grammes of solids in 1000 Cc.

Example.—Suppose the quantity of urine voided in 24 hours equals 1500 Cc., the specific gravity being 1.022, then with Häser's co-efficient we have as follows:

$$22 \times 2.33 = 51.26 \text{ Gm. in } 1000 \text{ Cc.}$$

But quantity we have equals 1500 Cc. Hence we have the following:

$$1000 : 1500 :: 51.26 : x = \frac{51.26 \times 1500}{1000} = 76.89 \text{ Gm. in } 1500 \text{ Cc.}$$

NORMAL CONSTITUENTS OF URINE.

INORGANIC CONSTITUENTS.

These comprise chiefly the chlorides, phosphates, carbonates, and sulphates, which occur as sodium, potassium, ammonium, calcium and magnesium salts. Fluorine, iron, and silicic acid are present in small quantities, as are also the gases, nitrogen and carbonic oxide, and lastly traces of oxygen are found.

The total amount of these salts varies from 9 to 25 Gm. per day. Their source is as follows: first, from the solids and liquids ingested; second, from the changes occurring constantly in the body tissues, the latter being chiefly responsible for phosphates and sulphates. Sulphates are derived from the proteids taken into the body, the sulphur in them becoming oxidized into sulphuric acid, which unites chiefly with metallic bases, but is also found in combination with organic radicles. The nitrogen of the proteid bodies is excreted as urea and uric acid.

CHLORIDES.

In normal urine we find chlorides chiefly as chloride of sodium, with small amounts of ammonium and potassium chlorides. These chlorides constitute, after urea, the main solid constituent of the urine and are excreted daily to the amount of from 10 to 16 Gm. corresponding to 6 to 10 Gm. of chlorine.

The excretion of chlorides is increased by active muscular exercise, and by the ingestion of foods containing much salt ($NaCl$).

With the body in a state of quiescence the amount excreted is diminished. On the whole, however, the amount of chlorides taken into the body, and the amount excreted, closely corresponds.

Exudative inflammations, particularly those into the serous cavities, cause a diminution in the excretion of chlorides, because in these conditions the dropsical fluid contains, as a rule, a liberal quantity of chlorides and other salts. Generally speaking, there is also a diminution of chlorides in the urine in acute febrile conditions, such as pneumonia, etc. In these conditions it is customary to observe the daily amount of chlorides excreted; a disappearance would be cause for alarm, while a gradual daily increase would indicate a probable favorable outcome.

Detection.—Usually the nitrate of silver test is employed. If much albumin be present it must first be removed. A small quantity, however, does not interfere. Nitrate of silver throws down both phosphates and chlorides, so it becomes necessary before applying the reagent to add a drop or two of nitric acid (HNO_3) to keep phosphates in solution. The reagent ($AgNO_3$) will cause a white, curdy precipitate, which is soluble in aqua ammonia but insoluble in nitric acid.

Determination.—Chlorides are determined quantitatively by means of decinormal solution of silver nitrate, giving preference

to Volhard's method (see page 431). The sample of either 10 Cc. or 10 Gm. of the urine is first acidified by means of a few drops of nitric acid before titrating. If it be desirable to estimate the per cent. by weight of chlorides, then 10 Gm. of the sample should be taken. If the chlorides are to be estimated as parts per volume, then 10 Cc., or any convenient volume, should be taken.

PHOSPHATES.

The phosphates of the urine consist partly of combinations of ortho-phosphoric acid (H_3PO_4), with the alkali metals, and partly of combinations with the alkaline earths, giving rise to the terms alkali phosphates and earthy phosphates.

The alkali phosphates of the urine are chiefly the acid phosphate of sodium and the phosphate of potassium, the former predominating.

These phosphates (unlike the earthy ones) are freely soluble in water and in alkaline fluids. They form the chief portions of the phosphates of the urine, being excreted daily to the amount of from 2 to 4 Gm. Upon this acid sodium phosphate (NaH_2PO_4) depends the acidity of the urine.

The earthy phosphates of the urine consist of the phosphates of calcium and magnesium, calcium phosphate being most abundant. From 1 to 1.5 Gm. are found in the urine excreted during 24 hours They are insoluble in water, but soluble in acids, consequently in an acid urine they are found in solution, while if the urine be of an alkaline reaction they are precipitated. The application of heat increases this precipitate, which fact often leads to an erroneous deduction regarding the presence of albumin in a given portion of urine. A slight acidification, however, will cause a prompt disappearance of this sediment (difference from albumin). Acid magnesium phosphate acted upon by ammonium forms the ammonio-magnesium phosphate, commonly spoken of as triple phosphate.

The alkali phosphates in the urine are derived from the food chiefly, and to a much less extent from the disintegration of nervous and muscular tissues. Therefore all conditions, such as inflammations, fevers, etc., which cause an abnormal activity of the vital functions would tend to increase the quantity of alkali phosphates in the urine. The earthy phosphates in the urine are found increased in diseases of the osseous system, such as rickets and osteomalacia; after great mental strain, in diseases referable to the nervous system and in such diseases as rheumatoid arthritis.

They are especially influenced, in regard to the quantity excreted, by the character of the food ingested. In certain renal diseases they are diminished. Earthy phosphates are often deposited as a result of nervous dyspepsia or as a result of overwork, or severe mental strain, a change in the reaction of the urine being the probable cause.

Quantitative Estimation of Total Phosphoric Acid.—The follow-

ing method is carried out by adding a volumetric solution of uranium nitrate to the sample of urine (kept hot) until all of the phosphoric acid is precipitated as insoluble uranium phosphate. To prevent any of the uranium phosphate from being dissolved by the nitric acid liberated in the reaction a solution of sodium acetate is added to the sample before titrating. The following solutions are necessary:—

1. A standard solution of uranium nitrate, containing 20.3 Gm. of pure uranium oxide * in 1000 Cc. of distilled water; each cubic centimeter corresponds to 5 Mg. of phosphoric acid.

2. A solution of sodium acetate; 100 Gm. of sodium acetate are dissolved in 900 Cc. of distilled water and sufficient acetic acid (30 per cent.) is added to make the fluid measure 1000 Cc.

3. A saturated solution of potassium ferrocyanide.

Assay.—Of the sample of urine 50 Cc. are measured into a beaker, adding 5 Cc. of the sodium acetate solution. The mixture is kept hot by means of a water-bath, and the uranium solution is added drop by drop as long as a precipitate falls. Toward the end of the reaction it is difficult to distinguish precipitation, hence we have recourse to the qualitative reaction with potassium ferrocyanide. To ascertain if the reaction is over or not, a drop of the mixture from the beaker is placed upon a porcelain plate and a drop of the potassium ferrocyanide solution is added; if a reddish-brown color does not appear, the addition of the standard uranium solution should continue until a reddish-brown precipitate appears, showing that sufficient of the uranium solution has been added to precipitate all of the phosphoric acid and that the slight excess of the reagent has formed a reddish-brown precipitate with the ferrocyanide solution. The volume of the uranium solution is read off, each cubic centimeter corresponding to 5 Mg. of phosphoric acid; from this the percentage is readily calculated.

Estimation of Earthy Phosphates (Calcium and Magnesium Phosphates).—To 200 Cc. of the urine excess of aqua ammonia is added; allow to stand 12 hours, then collect the precipitated phosphates on a filter and wash with ammoniated water (1 to 3). The filter is pierced at the point and the precipitate washed down into a beaker and then dissolved in as little hot acetic acid as possible. To this solution 5 Cc. of sodium acetate solution are added and then diluted to 50 Cc., and then proceed as above. The difference between the amount of total phosphates and that in combination with the alkali earths, represents the amount combined with the alkalies,—alkali phosphates.

SULPHATES.

The quantity of sulphates excreted during twenty-four hours is 3 to 4 Gm. They are chiefly those of sodium and potassium, the

* Or 20.3 Gm. of uranic oxide are dissolved in the smallest possible quantity of nitric acid and evaporated to dryness to remove all excess of nitric acid, then dissolved in water sufficient to make one liter.

former being in excess. They are derived partly from the body tissues and partly from the ingested food, and are increased by the ingestion of sulphur compounds, sulphuric acid and soluble sulphates. Active exercise and fevers also cause them to appear in the urine in increased quantities. An exclusively vegetable diet is said to decrease their excretion. In certain diseases, notably meningitis, muscular rheumatism and cerebritis, they appear in abnormal quantities.

Detection.—To a sample of the urine, add a few drops of hydrochloric acid, followed by test solution of barium chloride; the formation of a white cloud or precipitate indicates the presence of sulphates.

Quantitative Determination.—This consists in collecting and weighing the precipitate of barium sulphate; each 100 parts of barium sulphate correspond to 34.32 parts of sulphuric anhydride (SO_3) and 42.04 parts of sulphuric acid H_2SO_4. Any definite quantity of the sample (say 100 Cc.) is taken, heated to boiling in a beaker, adding about 5 Cc. of hydrochloric acid, then solution of barium chloride is added in excess until no more precipitation occurs. The precipitate is collected on a quantitative filter, well washed with boiling water, until the washings are free from barium salt, as shown by negative reaction with sulphuric acid. The filter and contents are placed in a platinum crucible and ignited, finally subjecting it to the heat of a blast lamp. The crucible is cooled in a desiccator and weighed; the tare of the crucible and weight of the filter-ash are then deducted, and the remainder represents the weight of the barium sulphate; this, when multiplied by the factor 0.4204, gives the weight of sulphuric acid present.

CARBONATES.

Fresh urine of an alkaline reaction contains very small quantities of carbonates and bicarbonates, chiefly those of sodium, ammonium, calcium, and magnesium. The presence of ammonium carbonate in large quantities always indicates decomposition. These carbonates are derived from the food. Urinary calculi sometimes have as their basis carbonate of calcium; in the human subject, however, this occurrence is rare.

The presence of carbonates or bicarbonates is made manifest by the addition of a few drops of an acid, causing effervescence from the liberation of carbonic acid gas.

IRON, SILICIC ACID AND FLUORINE.

Iron, silicic acid and fluorine occur in urine in very minute quantities, in unknown combinations.

GASES.

Carbonic acid gas, free and uncombined, is present in variable quantity, generally stated as from 4 to 9 volumes.

Oxygen, 0.2 to 0.6 Volume; and nitrogen, 0.7 to 0.8 Volume.

QUANTITATIVE ANALYSIS BY MEANS OF THE CENTRIFUGE.*

The chemical constituents of the urine, both normal and abnormal, may be estimated by the centrifugal method, and very excellent, as well as rapid, results may thus be obtained. The method followed by Purdy consists in throwing out of solution the chemical constituents of the urine desired to measure, and estimating the quantity of the insoluble precipitates in bulk percentage. For this purpose the author has devised a set of percentage tubes, which will be found convenient for estimating not only the chemical constituents of normal urine, but also such products of abnormal urine as pus, albumin, etc. These percentage tubes are graduated in tenths of a cubic centimeter up to 10 cubic centimeters. The lower portion of the tubes being drawn out in conical form, fractions of the first three cubic centimeters may be more accurately read and measured. Above the graduated scale the tubes possess sufficient capacity for the reception of the reagents ordinarily required to precipitate the urinary constituents to be estimated.† The following is Purdy's method of conducting centrifugal estimations of some of the inorganic constituents of the urine:—

CHLORIDES.

The percentage tubes are filled to the 10-cubic-centimeter mark with the urine to be tested; a few drops of nitric acid are added to prevent precipitation of the phosphates, and then the tubes are filled to the 15-cubic-centimeter mark with the standard nitrate-of-silver solution (ʒj to ℥j). The tubes are next closed and inverted several times, until the urine and the reagents are thoroughly mingled. The tubes are next placed in the centrifuge and revolved until the sediment is thoroughly packed, when the quantity in bulk percentage may be read off from the graduated scale on the sides of the tubes. From a considerable number of observations the author finds that the bulk percentage of chlorides in normal urine thus obtained ranges from 16 to 18 per cent. Variations from the normal range are quickly indicated, and the degree of variation is definitely measured.

PHOSPHATES.

The gross quantity of the urinary phosphates is readily determined by the centrifugal method in a similar manner. Thus, the percentage tubes are filled to the 10-cubic-centimeter mark with the urine to be tested, and then the magnesium mixture ‡ is added to the 15-cubic-centimeter mark. The tubes are closed

* The examples cited are selected from Purdy's Uranalysis.

† Elmer & Amend, of 205 and 211 Third Avenue, New York, manufacture and supply the author's percentage tubes for centrifugal analysis.

‡ The magnesium mixture consists of ammonium chloride and magnesium sulphate, āā 1 part; distilled water, 8 parts; and liquor ammonia, 1 part.

and inverted several times, until the urine and reagents are thoroughly mingled. The tubes are then placed in the centrifuge and revolved until precipitation is complete, when the bulk percentage may be read off from the scale.

The chlorides and phosphates precipitated as just described form comparatively heavy sediments, which are deposited by the centrifuge in about one minute. In order, however, to insure uniform results, it is found best to leave the tubes in the centrifuge for three minutes, when the sediments will be found to have packed so solidly that only long-continued revolutions cause further changes in the reading. With the electric centrifuge (page 495) it is advised to revolve the tubes uniformly three minutes, at *moderate speed,* before reading the quantity of chlorides and phosphates. One thousand revolutions per minute, continued for three minutes, give the author's standard results for chlorides, phosphates, and sulphates.

The bulk percentage of total phosphates in normal urine determined as just described will be found to range from 8 to 12 per cent. It may be observed that frequent and wide variations in the amount of urinary phosphates are more common than with any other urinary constituents. Quantitative centrifugal analysis can only be carried out satisfactorily with the electric centrifuge, because hand power cannot give the same uniform and definite rates of speed as electric power.

SULPHATES.

These are estimated as insoluble salts of barium, as follows: The percentage tubes are filled to the 10-cubic-centimeter mark with the urine to be tested; the acid barium-chloride mixture is next added to the 15-cubic-centimeter mark; * the tubes are then inverted a number of times, until the urine and reagents are mingled. The tubes are then placed in the centrifuge and revolved for three minutes, when the bulk percentage of total sulphates may be read off, the range of which in normal urine will be found about 1 per cent. The rule followed by the author with his electric centrifuge is as follows: *The chlorides, phosphates, and sulphates are sedimented in the percentage tubes by continued revolutions at moderate speed for three* (3) *minutes.*

The term *moderate speed,* wherever applied to the author's centrifuge, means 1000 revolutions per minute.

The author has found this method to give excellent approximate results for practical work, and the advantages of the method are that it can be carried out very rapidly and the variations from the normal standard are definitely measured. Centrifugal analysis may be extended to practically include all urinary constituents. Analysis for chlorides, phosphates, and sulphates are here described, both to illustrate the method and on account of the great practical value of being able so readily to approximately estimate

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* The acid barium-chloride solution is composed of 4 parts baric chloride, 1 part hydrochloric acid, and 16 parts distilled water.

these highly-important constituents. The author hopes soon to furnish methods and standards for centrifugal estimation of most, if not all, the remaining constituents of the urine.

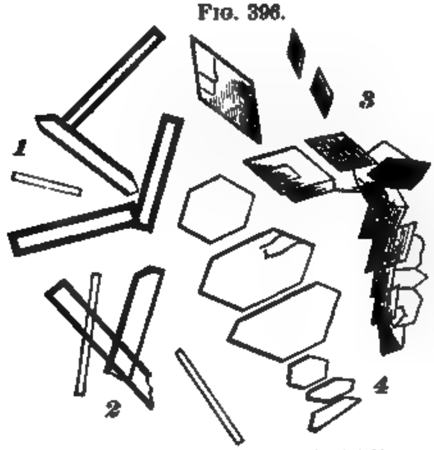
ORGANIC CONSTITUENTS.

PROTEIN DERIVATIVES.

UREA, $CO(NH_2)_2$.

This substance constitutes the most bulky single constituent of urine, the daily average amount ranging anywhere from 20 to 40 Gm. in the healthy adult. The greater portion of nitrogen taken into the system in the form of food is excreted by the kidneys as urea. It also appears in the economy as a

FIG. 396.



1, 2. Prisms of Pure Urea. 3. Rhomboidal Plates. 4. Hexagonal Tablets.

FIG. 397.

Crystals of Nitrate of Urea. (*After Beale.*)

result of that retrograde tissue metamorphosis which is constantly going on. The chief agency in its manufacture is the liver, though perhaps the spleen and lymphatic glands may be in a minor degree responsible for its production. That it is not manufactured in the kidney, but only excreted by that organ, is proven as follows: Upon extirpation of the kidneys, the formation of urea continues, and the agencies for its removal from the economy being absent, it consequently accumulates in the blood. The maximum quantity of urea is excreted as the result of a strict meat diet, the minimum quantity resulting from a vegetable diet, while from a mixed diet an intermediate quantity is formed. Urea occurs as colorless, quadrilateral or six-sided prismatic crystals or as delicate white needles, melting at 120° C. (248° F.). It is permanent in the air, soluble in water, and contains no water of crystallization. Upon the addition of nitric acid a combination takes place, resulting in the formation of nitrate of urea $CO(NH_2)_2HNO_3$. This occurs as octahedral,

hexagonal or lozenge-shaped crystals, less soluble in water than urea.

Urea may be prepared (from urine) as follows:—

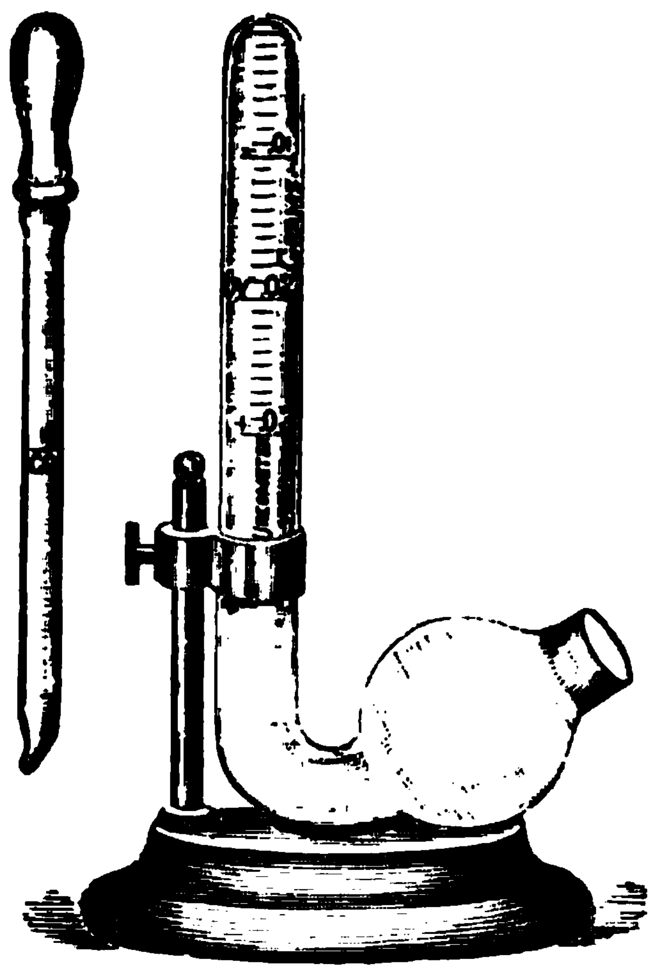
Evaporate, then add strong nitric acid in excess, keeping the mixture cool; the resulting crystals consist of nitrate of urea. Any excess of fluid is poured off, and the product is dried by pressing between folds of heavy filter paper. Now add barium carbonate and alcohol sufficient to render the mass of a pasty consistence. Evaporate on water bath to dryness, and extract with alcohol, filter, evaporate, and set aside to crystallize. The result will be nearly pure urea plus some coloring matter, which can readily be removed by filtration through animal charcoal.

Quantitative Determination.—Of the various methods proposed, that known as the "Hypobromite Method" of Knop is the most simple and convenient; the principle depending on the fact that when a solution of urea is brought into contact with a solution of sodium-hypobromite, nitrogen is liberated, as shown in the following equation:—

$$\underset{\text{Urea.}}{CO(NH_2)_2} + \underset{\substack{\text{Sodium}\\\text{Hypobromite.}}}{3NaBrO} = \underset{\substack{\text{Carbonic}\\\text{acid gas.}}}{CO_2} + 2H_2O + \underset{\substack{\text{Sodium}\\\text{bromide.}}}{3NaBr} + \underset{\text{Nitrogen.}}{2N}$$

The carbon dioxide liberated is absorbed by the excess of sodium hydrate present in the solution. One gramme of urea furnishes 370 Cc. of nitrogen at 0° C. and under a pressure of 760 Mm. For carrying out this determination the Ureometer of Doremus is the most convenient. The bulb of the instrument is filled with alkaline hypobromite solution,* and by inclining the tube, the long arm is filled to the neck of the bulb, leaving a slight vacuum space at the top of the tube. One Cc. of the sample of urine is measured off in the nipple-pipette and slowly discharged into the long arm containing the hypobromite solution, taking care not to force any air along into the apparatus. Rapid decomposition of the urea takes place, with evolution of nitrogen gas, which rises in the long arm of the instrument, displacing the solution which flows out into the bulb. The decomposition of the urea is complete in about 15 minutes, when the volume of nitrogen gas may be read off, indicating at once the quantity of urea in the volume of urine tested. The

FIG. 398.



Dr. Doremus's Ureometer.

* This solution should be prepared fresh when wanted. A stock solution of caustic soda, 100 Gm. to 250 Cc. of water, is made. When wanted for use 10 Cc. of this solution is measured off, and to it is added 1 Cc. of bromine, measured off by means of the nipple-pipette. When dissolved, the solution is diluted with an equal volume of water and is ready for use.

instrument is graduated to read fractions of a gramme to the cubic centimeter of urine, from 0.01 to 0.03 Gm. If it be desirable to read percentage of urea, instead of grammes per cubic centimeter of urine, the decimal point is removed two figures to the right, thus: 0.01 Gm. to the Cc., would read 1 per cent. of urea.

The normal quantity of urea in urine is about 0.02 Gm. per centimeter, or 2 per cent.

Differential Density Method.—This method, devised by Dr. G. B. Fowler of New York, answers very well for approximate results, it being very simple in application. The method is based on the difference in the specific gravity of urine before and after the decomposition of its urea by the hypochlorites. Each degree of density lost corresponds to 0.77 per cent., or about 3½ grains per ounce. To one volume of urine (50 Cc. or one fluidounce) add seven volumes of Labarraque's solution. Decomposition of the urea takes place, and after a few hours all of the nitrogen has escaped, after which the specific gravity of this mixture is taken with that of the sample of pure urine. In order to reduce the density of the decomposed and diluted urine down to its normal undiluted condition we multiply the specific gravity of the Labarraque's solution by 7, add the specific gravity of the urine, and divide the sum by 8. From the specific gravity before decomposition we subtract that after the decomposition and multiply the difference by 3½, giving as result the number of grains per ounce of urine, or by 0.77, which gives the percentage of urea.

URIC ACID ($C_5H_4N_4O_3$).

Uric acid exists in urine in comparatively small amounts, the daily quantity excreted averaging about 0.4 to 0.8 Gm. It is, like urea, a nitrogen derivative, and exists in the urine most often in combination, as urate of sodium, potassium and ammonium, rarer in combination with calcium or magnesium. It is so feebly soluble in water (14,000 parts of cold and 1800 of hot), that it is rarely, if ever, found in the free state. It is often, however, found in the form of a crystalline deposit appearing to the eye like red sand (urates). Two forms of urates are found in the urine, namely: acid urates, which are but feebly soluble in water, and neutral urates, which are freely soluble. In consequence of this different degree of solubility nearly all urate deposits are composed of acid urates. When a strong acid is added to urine containing an excess of soluble neutral urates, a fine granular precipitate results, rendering the mixture opaque. The reason for this change is as follows: The acid unites with the base to form acid urates, which on account of their feeble solubility are precipitated. This reaction often leads to errors in the application of the nitric acid test for albumin. Although there is considerable discussion regarding the formation of uric acid in the economy, it is more than probable that the liver is the chief seat of its production. It is never safe to assume the presence of excessive

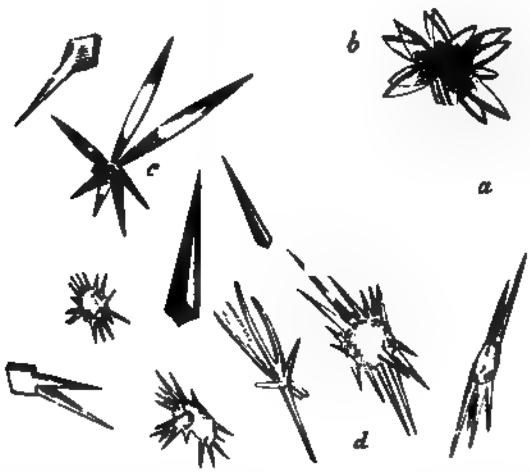
amounts of uric acid from the mere fact that a precipitate has occurred in the urine upon cooling. It is possible that such may be the case, coincident with a positive deficiency in uric acid, as, for instance, in a urine of high acidity.

Uric acid occurs as rhombic, rectangular prisms, whetstone and wedge-shaped, of yellowish-red color, constituting with its salts the only sediment of the urine thus colored.

Qualitative Detection.—The sediment or residue is moistened with nitric acid or chlorine water and evaporated to dryness in a porcelain capsule, then held over another dish containing aqua ammonia, a purple-red color indicating the presence of uric acid (murexid test).

Quantitative Determination.—One of the most reliable methods is that of Hopkins, in which the uric acid and urates are precipi-

FIG. 399.



More Unusual Forms of Uric Acid Crystals. (*After Harley.*)

tated by a saturated solution of ammonium chloride, as ammonium urates. From this precipitate the uric acid is liberated by the addition of hydrochloric acid, which is then estimated with a standard solution of potassium permanganate.

To 100 Cc. of the sample about 50 Gm. of ammonium chloride are added, and stirred until solution takes place. After a few hours, with occasional agitation, precipitation has taken place; the precipitate is collected on a filter and washed with a saturated aqueous solution of ammonium chloride. The precipitate is then washed off into a beaker and heated to boiling with an excess of hydrochloric acid, whereby on cooling, the uric acid completely separates; fully two hours should be allowed. The filtrate should be measured *before* the washing has begun, and 1 Mg. added to the final result for each 15 Cc. of fluid present (not more than 20

to 30 Cc.). The crystals of uric acid are washed off with hot water and warmed, adding sodium carbonate until dissolved, making the solution up to 100 Cc. To this is added 20 Cc. of H_2SO_4, and titrated with $\frac{N}{20}$ volumetric potassium permanganate solution, until the solution retains a faint pink color, each cubic centimeter being equivalent to 0.00375 Gm. of uric acid.

If the urine contain insoluble phosphates they should be filtered off after complete precipitation by heat.

Haycrofft's Method.—Deroide proposes an improvement of Haycrofft's method of uric acid determination, which depends upon the following reactions. Uric acid is precipitated by an ammoniacal solution of silver nitrate in presence of magnesia mixture; the resulting silver precipitate is dissolved in nitric acid. The precipitate contains to each one molecule of uric acid, one atom of silver. The silver is determined quantitatively by means of potassium sulphocyanide, employing ferric alum as indicator. The analysis is carried out thus: 50 Gm. of the urine is diluted with an equal amount of water; then to this is added 5 Cc. of Ludwig's silver solution (to a solution of 26 Gm. of $AgNO_3$ in the necessary quantity of water is added aqua ammoniæ, sufficient to dissolve the brown precipitate of silver oxide which at first forms) and magnesia mixture. The precipitate is collected on a filter, which is connected with a suction pump and thoroughly washed with water which contains aqua ammoniæ, until the filtrate is free from silver and chlorides. The precipitate is then dissolved on the filter with 20 to 30 per cent. nitric acid, washing until the filter is free from acid reaction. The nitric acid decomposes the silver urate into uric acid and silver nitrate. The clear solution is titrated with normal potassium sulphocyanide; each cubic centimeter corresponding to 3.36 Mg. of uric acid. Other nitrogenated products found in urine (xanthin, hypoxanthin) take part in the reaction; however, this error may be overcome by deducting the constant number 11 from the uric acid number. (Jour. Phar. Els.-Lothr.)

XANTHIN ($C_5H_4N_4O_2$).

This compound is closely allied to uric acid, containing one atom of oxygen less. It is present in only minute quantities in normal urine, and at times is deposited spontaneously in the form of yellowish-white brittle scales having a waxy consistence. It is readily soluble in alkalies and in dilute nitric and hydrochloric acids, feebly soluble in water, and insoluble in alcohol and ether.

Detection.—When dissolved in dilute hydrochloric acid, upon evaporation it separates into hexagonal crystals. When evaporated to dryness with nitric acid a yellow residue remains, which turns red with caustic potassium and reddish-violet on being heated.

ALLANTOIN ($C_4H_6N_4O_3$).

Allantoin occurs as a mere trace in normal urine, except

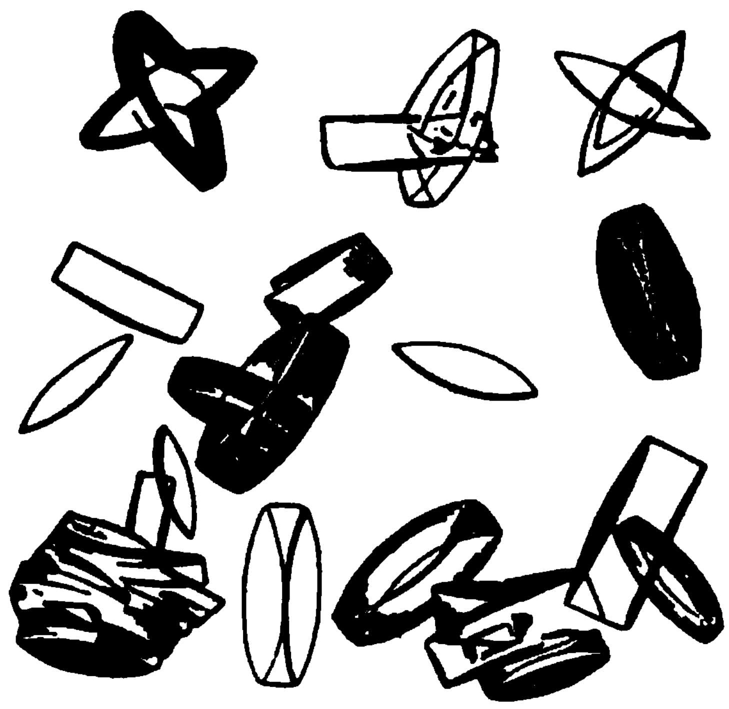
directly after birth. It is increased by a meat diet, and by the ingestion of tannic acid. It may be prepared from uric acid by oxidation with potassium permanganate. It crystallizes in colorless prisms, which are soluble in hot water, but slightly so in cold water, and insoluble in alcohol or ether. Mercuric salts precipitate it from its solutions.

Detection and Determination.—Allantoin may be separated from urine as follows: precipitate with lead acetate, filter, and pass sulphuretted hydrogen through the filtrate, filter again, evaporate to a syrupy consistence, and let stand for several days or until crystallization takes place.

CREATININ ($C_4H_7N_3O$) AND CREATIN ($C_4H_9N_3O_2$).

Chemically these bodies differ in the fact that creatin contains one molecule of water more than creatinin. They are both constituents of normal urine, and depending on certain conditions, are interchangeable with one another. In urine of an acid reaction creatinin appears more abundant, while in an alkaline urine, the reverse is true. As the urine is mostly acid in its normal condition, creatinin is looked upon as the normal constituent. It crystallizes in large colorless prisms, soluble in water and alcohol, but almost insoluble in ether, and exhibits a decided alkaline reaction with test paper. It is excreted in nearly the same amount as uric acid—.05 to .09 Gm. in 24 hours. Creatinin and creatin are both probably derived from the ingested food.

FIG. 400.



Creatinin Crystals. (*After Kuhn.*)

Detection and Determination.—

(*a*) Weyl's Test.—If to a dilute solution of creatinin, a solution of sodium nitro-prussiate be added, with a subsequent addition of sodium hydroxide a red color appears, which changes to yellow upon standing.

(*b*) Acidulating a solution of creatinin with nitric acid, and adding phospho-molybdic acid, causes a yellow crystalline precipitate to appear, which is soluble in hot nitric acid.

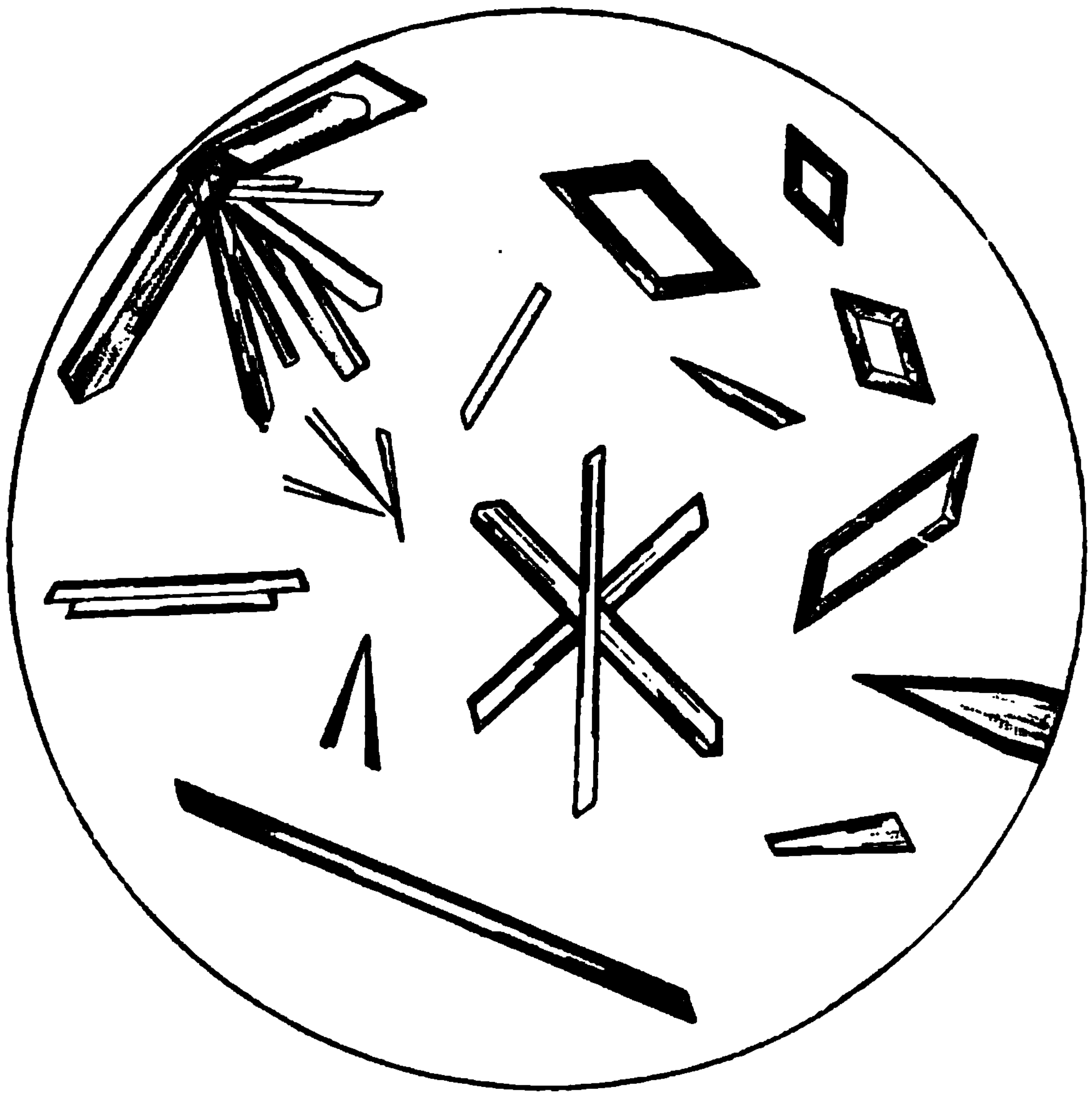
(*c*) Quantitative Test.—With zinc chloride it gives a crystalline precipitate consisting of a combination of zinc chloride with creatinin. This test is employed for quantitative estimations.

GROUP OF AROMATIC SUBSTANCES.

HIPPURIC ACID ($C_9H_9NO_3$).

Hippuric acid, although a constant element of normal urine, is excreted in small amounts, 0.5 to 1 Gm. daily. The quantity excreted is, however, subject to considerable variation, depending chiefly upon the character and quantity of the food eaten. A vegetable diet, especially certain fruits, cranberries, prunes, etc., increases the quantity excreted daily. The administration of certain drugs, such as oil of bitter almonds, benzoic acid, toluol, benzylamin, cinnamic acid, kinic acid, and phenylpropionic acid, also cause an increased daily excretion. An animal diet de-

FIG. 401.



Hippuric Acid Crystals. (*After Peyer.*)

creases its elimination, although it never in man entirely disappears from the urine, though he be placed upon an exclusive meat diet.

It is a monobasic acid and crystallizes either in the form of fine needles or four-sided prisms and pillars.

It is colorless, odorless, and has a slightly bitter taste; soluble in 600 parts of cold water, and very soluble in hot water, ether, and alcohol.

Detection and Determination—(*a*) Urine with nitric acid are subjected to evaporation; if hippuric acid be present the characteristic odor of nitro-benzol is given off.

(*b*) If the urine contain an excess of hippuric acid, it may be

determined by slightly concentrating and feebly acidulating with hydrochloric acid. After standing a few hours, crystals of hippuric acid begin to separate and may be recognized under the microscope. If uric acid be present in sufficient quantity to interfere with the test, it becomes necessary to remove the hippuric acid by means of hot water.

ETHEREAL SULPHATES.

The most important of this series are the ethereal potassium sulphates of phenol, creosol, catechol, indol, and skatol. They are found in larger quantities in the urine of herbivora than in that of the carnivora or omnivora. The proportion of these ethereal sulphates to the total sulphates of the urine is 1 to 10. They originate as follows: (*a*) From aromatic substances ingested with the food; (*b*) as a result of putrefactive changes in the intestines. In man the latter source would seem to be the chief one. The relation which the ethereal sulphates bear to the total sulphates eliminated, can be employed as a guide to the amount of putrefactive changes occurring in the economy.

The most important of these compounds is the indoxyl potassium sulphate $C_8H_6NOSO_3K$, this has been erroneously called indican, because it was supposed to be identical with vegetable indican.

It occurs in white plates or tablets, freely soluble in water, less so in alcohol, and with oxidizing agents it yields indigo blue. The different colored urines met with in disease, such as blue, green, and sometimes red, probably owe their color to this salt, the particular color depending upon the degree of oxidation.

Detection.—(*a*) McMunn's method:—Boil together equal parts of urine and hydrochloric acid with a few drops of nitric acid, cool, and agitate with chloroform. The chloroform assumes a violet color, and shows an absorption band before D. due to indigo-blue, and another after D. due to indigo-red.

(*b*) Jaffe's method:—Mix 10 Cc. of strong hydrochloric acid with an equal quantity of urine in a test-tube, and while shaking add drop by drop a fresh saturated solution of chloride of lime, or chlorine water, until the deepest attainable blue color is reached. Next agitate with chloroform, which takes up the indigo and holds it in solution. The quantity can be estimated approximately by the depth of the color.

Any albumin that may be present must first be removed before these tests can be applied. Hydrochloric acid added to urine containing albumin often causes a blue coloration to appear, and this would manifestly lead to erroneous conclusions.

(*c*) Add to 4 Cc. of hydrochloric acid from 10 to 20 drops of urine, constantly stirring. If a light yellow color appears, the proportion of indigo is about normal; if violet or blue, it is in excess.

In addition to indoxyl potassium sulphate the urine contains

other compounds belonging to the same class—viz., phenol potassium sulphate, creosol potassium sulphate, catechol potassium sulphate, and skatoxyl potassium sulphate. They are present in small quantities and possess no special significance.

PIGMENTS OF THE URINE.

NORMAL UROBILIN.

Normal urobilin is a dark brown, amorphous, almost resinous substance, sparingly soluble in water, but readily so in alkali solutions, alcohol, ether, chloroform, and acids.

It is the chief coloring agent of normal urine, but not the only one. Its origin is somewhat in doubt, being probably derived from the reduction of bilirubin by nascent hydrogen. It exists in normal urine in small amounts only, being much increased in acute fevers. Conditions favoring the destruction of red blood-corpuscles cause a marked increase in the excretion of urobilin, and, conversely, such conditions as anæmia and chlorosis show a marked decrease in its excretion.

Detection.—Render urine alkaline by addition of ammonium hydroxide and filter, add to filtrate chloride of zinc solution, and observe, if urobilin be present, a green fluorescence.

UROERYTHRIN.

The origin of this substance, or its relation to the other coloring matters, are unknown. To it is due the reddish tint that characterizes the urates, and from them it can be removed by treating with alcohol. Potassium or sodium hydroxide added to it turns it green.

UROCHROME.

This pigment contains a large quantity of urobilin, and is thought by some to consist of impure urobilin. It occurs in yellow scales, soluble in ether and dilute acids, partly soluble in water, and less so in alcohol.

By oxidation it yields uroerythrin.

The other organic constituents of the urine, such as acids like oxalic acid, lactic acid, etc., carbohydrates, ferments, mucin, etc., are not of sufficient importance to demand any special enumeration.

ABNORMAL CONSTITUENTS OF URINE.

PROTEIDS.

We meet in certain pathological conditions of the renal organs, the blood, or the economy at large, various proteid bodies in the urine. Chief among them are the following—serum-albumin, serum-globulin, fibrin, and hæmoglobin. These proteid bodies, when found in the urine, are derived from the blood, which has,

owing to some pathological condition, allowed them to escape. Egg albumin sometimes occurs in urine after partaking liberally of eggs, although this proteid is not a normal constituent of the blood. Lastly, certain bodies, which are the intermediate products in the conversion of proteids into peptones, and are known as proteoses, and, indeed, their final product, peptone, may be found in the urine, although not pre-existing as such in the blood. The proteid, however, that is of chief interest in a clinical sense is serum albumin.

ALBUMINURIA.

The presence of serum-albumin in the urine is rendered possible by one or more existing pathological conditions. Principal among these are: first, changes in the degree of blood pressure; second, changes in the quality of the serum-albumin, or changes in the quality of the blood (without reference to the albumin) which render the latter more diffusible; third, changes in the structure of the kidney. Viewed from a clinical standpoint, the latter condition is of the most importance, and is usually found in the class of disorders grouped together under the term Bright's Disease. There is, however, no fixed and definite relations between the amount of albumin in the urine and the gravity of the renal disorder. It is possible that in cases of marked kidney lesions, the amount of albumin will be small, and conversely a large amount of albumin is often found in cases with but a moderate amount of actual lesion.

The class of albuminurias depending upon changes in the blood are frequently met with, particularly in anæmic, strumous, or enfeebled individuals where no proper kidney lesion can be demonstrated. Albumin in these cases escapes into the renal tubules and into the urine, because its diffusibility has become altered, the alteration depending upon changes in the constitution of the blood. These changes in the blood may also be produced by the ingestion of drugs, mainly poisons, by infectious fevers, or by micro-organisms.

Disturbances of the circulation, such as a slowing of the venous current or an acceleration of the arterial flow, often cause albuminuria without change in the kidney structure. If, however, these circulatory disturbances be long continued, they will finally result in structural changes in the renal organism. In order that these disturbances produce albuminuria it is evident that the renal circulation must participate in them.

Another form of albuminuria, known as Cyclic Albuminuria (Pavy's), or Albuminuria of Adolescence (Moxen's), is met with. It occurs mainly in youths or young adults, and its cause may probably be referred to one or more of those above mentioned.

The presence of albumin in the urine can never be accepted as positive proof of the existence of a renal lesion, but when, in ad-

dition to albumin, a given urine contains casts, epithelium, and other evidences of a destructive process going on in the kidney, it becomes established beyond doubt that the albuminuria is due to renal disease.

The term spurious, false, adventitious, or accidental albuminuria is applied to such cases where the kidney is not the source of the albumin. The urine, as secreted by the kidney, is perfectly normal, but becomes albuminous, owing to an admixture of the products of inflammation from some portion of the urinary passages.

DETECTION OF ALBUMIN IN URINE.

(*a*) *Heat.*—This test is usually employed in conjunction with nitric acid. Fill a test-tube half full of the suspected urine, and apply heat until the entire liquid boils. If precipitation occur it is either due to separation of albumin or of earthy phosphates; if the latter be the case, a few drops of nitric acid added will redissolve the precipitate. If the precipitate on the addition of nitric acid remain undissolved, it is due to the presence of albumin. It is well to add the acid in small quantities at first—say 3 to 5 drops—and then reboil the urine. If now no precipitate occurs, acidulation is to be continued until a precipitate is formed or the limit of acidification be reached, say when about 20 drops of acid have been added.

The test may be reversed, that is, the acid may be added before heat is applied.

Sources of Error.—If albumin be present in small quantities, and much acid be used, syntonin, or acid albumin, may be formed, which is not precipitated by heat.

Conversely, if the acid be added in insufficient quantity to distinctly acidify the urine, and phosphates be present in excess, only a part of the phosphates can combine with the acid, while the remainder may combine with the albumin, forming a compound, alkali albumin, which is not precipitated on boiling.

Globulin and mucin are also precipitated by this test.

(*b*) *Purdy's Method.*—The modification of the heat and acid test devised by C. W. Purdy is a most excellent method for the detection of minute quantities of albumin. This method avoids the mucin reaction, so liable to occur with the heat and acid test, while it possesses all the sensitiveness of the latter test for albumin. It may be applied, according to the author, as follows:—

Have at hand a solution of chloride of sodium, prepared by saturation and filtering, so that it is perfectly clear. First raise the specific gravity of the urine about 10 to 15 degrees by the addition of a little of the sodium chloride solution. Next fill an ordinary test-tube to about two-thirds with the urine, add 1 or 2 drops of strong acetic acid, and boil the upper inch or so of the urine about half a minute over a spirit lamp. Examine in a good light, and if albumin be present it will appear in the upper boiled

portion of the urine as a more or less pronounced milk-like turbidity, according to the quantity present, the lower or unboiled portion remaining perfectly clear, in strong contrast.

(c) *Nitric Acid Test.*—This test is best applied by the contact, or Heller's method, as follows: Upon a quantity of pure nitric acid, in a test-tube, allow to flow carefully, so the liquid will overlie the acid, an equal volume of the suspected urine. This is best accomplished by holding the test-tube in an inclined position, the urine being permitted to flow slowly down the side of the tube. If albumin be present, there appears at the point of contact, between the two liquids, a white band or zone, varying in thickness according to the amount of albumin present. If only a trace of albumin be present in the suspected urine, the reaction may be delayed for some time; if, therefore, there be no immediate change perceptible, the tube must be set aside and re-examined, say in about half an hour.

In concentrated urine a somewhat similar white zone is formed by the reaction of nitric acid with the mixed urates. The cloud of urates, however, appears not so much at the border, between the liquids, as higher up; that is, within the urine. The cloudiness from this source may be made to disappear upon the application of gentle heat.

If mucin be present in excess, a light cloud may make its appearance near the surface of the urine layer, mucin being precipitated by dilute nitric acid, such as would be found in the upper strata of the liquid. This test, as well as the test by heat, may cause a slight precipitation if pine acids be present, such as may occur in the urine after the use of copaiba and cubebs. This cloudiness is, however, readily distinguished from that caused by albumin by its solubility in alcohol.

(d) *The Ferrocyanic Test.*—This test, applied by the following method (Purdy), avoids the mucin reaction, and precipitates all modifications of albumin, acid and alkaline. It may be applied as follows:—

Fill a test-tube half full of urine, and add about a drachm of a 1 in 20 potassium ferrocyanide solution. Mix the urine and reagent thoroughly, and add 10 or 15 drops of acetic acid, and if albumin be present, an immediate reaction takes place, the albumin being precipitated throughout the entire volume of the urine.

The acid employed in this test must never be first added to the urine, as it precipitates urinary mucin. It is only by first adding the ferrocyanide solution to the urine that the difficulty is overcome. If the test is applied as above, only albumin will be precipitated.

Potassio-Mercuric Iodide Test.—This test was first suggested by Tanret as a most sensitive test for albumin. It responds to all kinds and modifications of albumin, also to peptone and the proteoses, as well as to vegetable alkaloids and pine acids. All reactions, however, other than with albumin, the pine acids, and

mucin, disappear upon gently heating. Its formula is as follows: Bichloride of mercury, 1.35 Gm.; potassium iodide, 3.32 Gm.; acetic acid, 20 Cc.; distilled water, to 100 Cc. Dissolve the salts separately in water, mix the solutions, and add the acetic acid and water. The test is applied by the contact method, the reagent, being of a high specific gravity (about 1040), is first introduced into the test-tube and the urine made to overlie it.

Picric Acid.—This test has an able exponent in Dr. Johnson, of London. The solution is prepared by saturation, 6 or 7 grains of picric acid to an ounce of distilled water. Urine to the depth of 4 inches is placed in a test-tube and upon this is floated the reagent, which, owing to its low specific gravity, only mingles with the upper strata of urine. If albumin be present it will be coagulated, and render the mixture turbid. The test precipitates albumin, peptone, mucin, proteoses, and vegetable alkaloids, all save mucin being dissolved upon the application of heat.

Sodium Tungstate.—This test is applied by the contact method, and precipitates, in addition to albumin, peptone, mucin, and perhaps the urates. No precipitate obtains with the alkaloids, and all precipitates except those of mucin and albumin are dissolved by heat. The solution is prepared as follows: Mix equal parts of sodium tungstate solution (1 to 4) and saturated solution of citric acid (10 to 6).

Acidulated Brine.—This test is offered by Roberts, and the solution is prepared by mixing together a pint of a saturated solution of common salt and 1 fluidounce of hydrochloric acid, and filtering. The contact method is employed, first introducing the reagent into the test-tube.

Nitric Magnesium Test.—This is another test offered by Roberts. The solution is prepared by adding one ounce of strong nitric acid to 5 ounces of saturated solution of magnesium sulphate. Employ the contact method.

Phenic-Acetic Acid Test.—This test is known as Millard's test, and was claimed by him to be the most sensitive of all albumin tests.* It is prepared as follows: Acid phenic glacial (95 per cent.), ʒij; acetic acid (C. P.), ʒvij; liquor potassæ, ʒvj. This reagent precipitates albumin, as well as peptone, mucin, alkaloids, and the pine acids; the peptone and alkaloids being dissolved upon the application of heat. The test is applied by the contact method, the urine overlaying the reagent.

Trichloracetic Acid Test.—Prepare solution by saturating distilled water with the acid (about ℥ss to ℥j of water), and apply by contact method.

Heynsius's Test.—Render the urine strongly acid with acetic acid; then add a few cubic centimeters of saturated solution of sodium chloride and boil the mixture, when if albumin be present it is coagulated.

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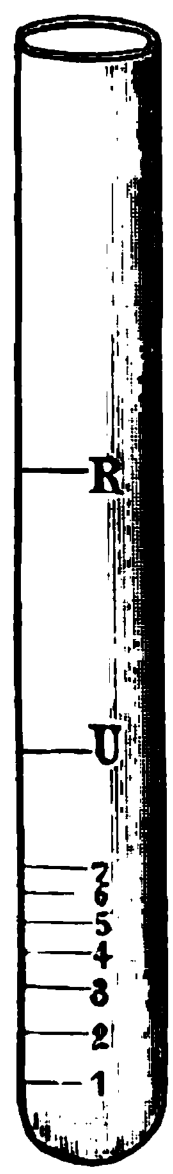
*Crystallized Carbolic Acid.

Heidenlang's Test.—Add to the suspected urine a little metaphosphoric acid; if albumin be present, a white precipitate is formed.

Acetic Acid and Sodium Sulphate.—One drachm of a urine strongly acidulated with acetic acid is added to 1 drachm of a strong solution of sodium sulphate and boiled. If albumin be present a precipitate will result.

Biuret Test.—This test reacts with albumin, albumose, globulin, and peptone, with the latter yielding a red color. Heat the urine with caustic potash, and add, drop by drop, with aid of a pipette, a dilute solution of cupric sulphate. If albumin be present, the resulting cupric peroxide (a green precipitate) is dissolved, the fluid assuming a reddish-violet color.

FIG. 402.



Esbach's Albuminometer.

Millon's Test.—To 1 drachm of urine, 10♏ of Millon's reagent are added and heat applied. If albumin be present in considerable quantity, a white precipitate is the result, which assumes a red color upon heating. If minute quantities of albumin are present the fluid becomes red, but no precipitate is formed. The test is not reliable.

Xanthoproteic Reaction.—Concentrated nitric acid is added to the suspected urine and the mixture boiled. Upon cooling ammonium is added, when, if albumin be present, an orange color is produced.

Saturated Paper Tests.—A number of the more common albumin tests have been prepared and used in the paper form. These papers are prepared by saturation with citric acid and with solution of the albumin reagents; chemically pure filtering paper being employed. They are used as follows: Place a paper charged with citric acid, together with one charged with the albumin reagent, in a test-tube containing say about one drachm of distilled water. After agitation remove the papers, and to the solution thus obtained add the urine, preferably by the contact method.

Quantitative Determination.—In expressing the percentage of albumin present in a sample of urine, only the *weight* of albumin present should be considered, and not the volume or bulk occupied by the precipitate. Such methods as the latter are capable only of yielding approximate results. Where the albumin has been coagulated by the addition of a reagent, it should be filtered off, washed, dried at 100° C., and weighed. It is necessary in such a gravimetric estimation that 100 Cc. or more of the sample be taken. The various ready methods for the quantitative determination of albumin depend on its precipitation in a graduated tube and measuring the *bulk* percentage.

Esbach's Method.—For this purpose a graduated tube called an albuminometer (Fig. 402) is employed. The tube is filled with

the sample of urine up to the letter U, then the test solution of picric acid * is added up to R; close well with the stopper and mix well by inverting several times. Set aside for 24 hours, and then read off the number of grammes of albumin per liter as indicated by the figure at the level of which the albumin settles. If it is desired to know the volume percentage of albumin, remove the decimal point one figure to the left; thus 2 Gm. per liter would be 0.2 per cent. of albumin. The chief objection to this method is that the reagent (picric acid) throws out and measures peptones, mucin, the proteoses, and proteids all together.

Purdy's Centrifugal Method.—This consists in precipitating the albumin by means of potassium ferrocyanide in a centrifuge (Fig. 404). The graduated tubes (Fig. 405) are filled to the 10 Cc. mark with the sample of urine, and 3.5 Cc. of potassium ferrocyanide (1 in 10) solution are added, the two well mixed, and then placed in the centrifuge and revolved until all the albumin has settled, leaving the fluid above perfectly clear. The volume percentage of albumin is read off, each $\frac{1}{10}$ Cc. corresponding to 1 per cent. by volume of albumin. This reagent precipitates only albumin, hence quite reliable.

CARBOHYDRATES.

A number of representatives of this class are found in the urine, the one of the greatest clinical interest and importance being glucose. Occasionally small quantities of levulose, lactose, inosite, and others may be found, but they do not possess the importance or significance of glucose.

GLUCOSE OR GRAPE SUGAR.

Grape sugar is found in minute quantities in normal blood, the exact amount depending upon the functional activity of the liver. Abnormally in certain conditions the amount of sugar in the blood is largely increased. It is still a disputed question whether glucose exists in the normal urine or is absent therefrom. Recent researches have made it appear that there are present in normal urine traces of glucose; the amount, however, is exceedingly minute, cannot be detected by the ordinary methods, and has no clinical interest. This substance crystallizes in rhombic tablets, is soluble in about its own weight of water, and has dextro-rotatory powers (+ 56°). When boiled with solutions of caustic potash it becomes brown, but with picric acid it assumes a deep red color. If a faintly alkaline solution of grape sugar, colored blue by indigo, be boiled, it exhibits a beautiful color reaction, beginning with violet and ending in yellow. It also has the property of reducing salts of silver, mercury, bis-

* Picric acid 10 Gm., citric acid 20 Gm., distilled water sufficient to make 1000 Cc.

muth, and copper in an alkaline solution, the cupric salts becoming reduced to the cuprous condition, while metallic silver, mercury, and bismuth are thrown down. With solutions of sodium acetate it reduces phenylhydrazin hydrochloride to phenylglucosazone, forming the characteristic golden-yellow crystals of this compound.

Glucose may appear in the urine as a temporary condition during the course of many diseases, and as the result of the ingestion of certain drugs and toxic substances. It may be caused in a mild form by gastric disorders and in some by the over-ingestion of starchy or saccharine foods. These are, however, only transitory conditions. It is the persistent presence of glucose in the urine to which we turn our attention. This condition may be followed by such grave results that the prompt detection of glucose in the urine becomes of the greatest importance.

TESTING FOR SUGAR IN URINE.

A great many tests have been offered and employed for the detection of sugar in the urine. In employing any one of the numerous copper tests, it is well to add a minimal amount of urine to the test solution, gradually increasing the amount if no reaction occur until a stated quantity has been added. We may thus obtain a rough estimate of the quantity of sugar present, as well as lessen the chances of reduction by substances in the urine other than sugar.

It is always well after the application of any of the tests, particularly if there be any doubt regarding the presence of sugar, to confirm its presence or absence by means of some of the other tests described, the phenylhydrazin test being probably the most reliable and sensitive one, this substance reacting with few substances in the urine other than glucose.

It is generally stated that in applying the copper tests, it is necessary to first remove any albumin that may be present, supposing albumin to interfere with the reduction of the cupric oxide. To this Purdy takes exception, except as far as it relates to the bismuth test.

Boiling should not in general be continued over half a minute, as urine absolutely free from sugar, if boiled a long period with a test solution, will show a slight reduction; this is evidenced by a greenish opacity. It must also be remembered that strongly alkaline solutions precipitate the earthy phosphates of calcium and magnesium in the form of a grayish cloud, which may constitute a source of error, giving rise to precipitates which might be mistaken for a sugar reaction by the inexperienced. Should the sample contain mucus or be turbid it should be shaken first with some kaolin or calcium phosphate (precipitated), then filtered, yielding a bright, clear solution ready for testing. When testing urine by alkaline copper solutions, it is well to first add a

few drops of caustic soda solution to the boiling urine to precipitate the phosphates, then after filtering apply the desired tests.

DETECTION OF SUGAR IN URINE.

(*a*) *Trommer's Test.*—A convenient application of this test may be made as follows: Treat in an ordinary test-tube about one drachm of urine with enough solution of cupric sulphate to render it light green, then add an equal volume of liquor potassæ. The result will be a blue precipitate consisting of the hydrated cupric protoxide. Upon shaking, this blue precipitate dissolves, forming a clear, blue solution. If allowed to stand for a time, a gradual reduction occurs, especially if sugar be present in large quantities, with a resulting precipitate of yellow or yellowish-red suboxide of copper. Reduction occurs at once if gentle heat be applied to the solution, instead of allowing it to stand.

The test may be criticised as follows:—(*a*) It is not very sensitive, unless boiling be resorted to, detecting sugar only if present in large quantities. (*b*) If boiled long the test is rendered over-sensitive, so that a reduction may occur with constituents of the urine other than sugar. The power of reducing cuprous oxide in alkaline solutions is possessed, to a certain degree, by such non-saccharine substances as uric acid, creatin, creatinin, etc.

(*b*) *Fehling's Test.*—The original formula for Fehling's solution is as follows: 34.639 Gm. of pure crystallized cupric sulphate; about 500 Cc. of a sodium hydroxide solution (specific gravity 1.12); chemically pure neutral sodium tartrate, 173 Gm. Dissolve the copper sulphate in 100 Cc. of distilled water; next dissolve the neutral sodium tartrate in the caustic sodium solution, and add the copper solution little by little; finally, with distilled water bring the volume of the whole to 1000 Cc. (1 liter).

The test can be applied in the following manner: A convenient quantity of the test solution is placed in a test-tube and raised to the boiling point. The solution should remain clear. Add now a small quantity of urine and continue the boiling, and if considerable sugar be present the solution will assume an opaque yellow color, and following this a yellowish-red precipitate is thrown down. Should the reaction not occur, more urine may be added, such quantity not to exceed in volume that of the test solution; then if upon boiling no yellow precipitate be thrown down, the urine may be considered free from sugar.

A serious objection to the use of Fehling's solution is its tendency to decompose upon keeping. It should, therefore, always be freshly prepared when wanted for use.

(*c*) *Haines' Test.*—The best qualitative test for sugar, having copper for its basis, is that devised by Professor Haines. It is applied as follows: Take about one drachm of the solution (see formula below) and gently boil it in a test-tube, add from six to eight drops of the suspected urine, and continue the gentle boiling. If sugar be present there will be thrown down a yellow or yellow-

ish-red precipitate. The solution is prepared as follows: Thirty grains of chemically pure copper sulphate are dissolved in one-half ounce distilled water; after complete solution is effected add one-half ounce pure glycerine, mix thoroughly, and finally add five ounces of liquor potassæ.

(*d*) *Böttger's Test.*—The test depends upon the fact, first suggested by Böttger, that grape sugar possesses the property of reducing bismuth salts with formation of a black precipitate. It may be applied as follows: Add to the urine an equal volume of liquor potassæ and then some subnitrate of bismuth. Boil gently, and if sugar be present, a precipitate, either gray or black, depending upon the quantity of sugar present, will occur. Sulphur if present will give the same reaction, consequently it is necessary to first remove any albumin that may be present.

Brücke's Modification of the Bismuth Test.—To meet the difficulty due to the presence of minute quantities of sulphur, which causes a black precipitate of sulphate of bismuth, Brücke suggests the use of Frohn's * reagent—iodide of bismuth and potassium—to remove the disturbing elements as follows:—

Take two test-tubes, pour into one a certain quantity of water, and into the other the same quantity of suspected urine. To the first add hydrochloric acid until a drop of Frohn's reagent no longer produces a cloudiness. In this manner the quantity of hydrochloric acid that must be added to the urine is obtained approximately. Acidify the urine with this quantity, treat it with the reagent, and filter. The filtrate, which now, upon addition of either the reagent or hydrochloric acid, should remain clear, is boiled with solution of caustic potash or soda, as in Böttger's test; and if a gray or black color results, sugar is present.

Nylander's Test.—Ten parts of the sample of urine are boiled with one volume of Nylander's Reagent for from two to five minutes; if as much as 0.025 per cent. of sugar be present, a gray to black precipitate forms. This reagent is prepared by dissolving 2 Gm. of bismuth subnitrate and 5 Gm. of Rochelle salt in 100 Gm. of an aqueous solution of caustic soda of density of 1.119 containing about 10.33 per cent. of NaOH.

(*e*) *The Fermentation Test.*—In the fermentation set up by yeast, grape sugar is decomposed with the formation of alcohol, carbon dioxide, succinic acid, and other products. Consequently, if yeast be added to urine containing grape sugar, such a reaction will occur, with a resulting decrease in the specific gravity of the urine. The test may be applied as follows: Fill a test-tube half full of mercury, and the remaining half with the suspected urine, and introduce into the urine a small piece of yeast. Invert the test-tube over a small vessel of mercury, and set aside in a

* Frohn's reagent is prepared by using 1.5 Gm. of freshly precipitated subnitrate of bismuth with 20 Gm. of water, heated to boiling, then 7 Gm. of potassium iodide and 20 drops of hydrochloric acid are added. The reagent should be orange-red.

warm room for several hours. If sugar be present, fermentation begins very soon, with a resultant liberation of carbonic acid gas, which collects in the upper end of the tube, displacing the mercury and the urine.

To render this test available, urine must contain a considerable quantity of sugar, 1 per cent. or over; the detection of small quantities is uncertain, owing to the fact that urine is capable of absorbing a considerable amount of carbonic acid gas. Another disadvantage of this test in its practical application is the fact that it requires several hours to obtain the desired result. A precaution should be observed whenever this test is applied. Some specimens of yeast evolve gas spontaneously, and it therefore is advisable to perform a parallel experiment with yeast and water so that any gas evolved in this manner can be estimated.

(*f*) *Phenylhydrazin Test.*—Trustworthy results may be obtained

FIG. 403.

Phenylglucosazone Crystals from Urine Containing Sugar.

by this test with every variety of abnormal urine, whether albumin be present or not. The test depends upon the property, possessed by phenylhydrazin hydrochloride, of forming with grape sugar a characteristic compound. It may be applied as follows: Add to 25 Cc. of suspected urine 1 Gm. phenylhydrazin hydrochloride, 0.75 Gm. sodium acetate, and 10 Cc. of distilled water; place the whole in a capsule and warm over a water bath for at least an hour, then remove and allow to cool. If sugar be present, even though in minute quantities, a yellowish deposit is formed, appearing amorphous to the eye, but showing fine, bright-yellow, needle-like crystals under the microscope. They are the characteristic crystals of phenylglucosazone, melting at 204° C. A yellow, scaly deposit or brown spherules must not be confounded with the bright yellow crystals. The mixture must be in the water bath for at least an hour, otherwise a crystalline glycuronic-

acid compound, having its melting point 150° C., is formed and may be mistaken for phenylglucosazone.

(*g*) *Wender's Methylene-Blue Reagent.*—Dilute 5 to 10 Cc. of the urine tenfold; place 1 Cc. of the dilution, 1 Cc. of a 1:1000 aqueous solution of methylene blue, and 3 Cc. of $1\frac{n}{1}$ potassa solution into a test-tube, and dilute with 2 Cc. of distilled water; then heat over an open flame until it boils up several times. If sugar be present, a total discoloration of the fluid will occur; and if the color remains unchanged, the urine is not diabetic.

(*h*) *Mulder's Indigo-Carmine Test.*—Take a small quantity of 1:1000 solution of indigo-carmine, and render it alkaline with sodium carbonate; boil with half its volume of the diabetic urine. The color will change in the following order: From blue to purple, red, yellow, and finally straw color. After cooling, the colors are reversed, the original blue color being gradually returned to.

(*i*) *Safranine Test.*—Boil 1 Cc. of the urine with 2 Cc. of potassa solution and 5 Cc. of a 1 per cent. solution of safranine. If there is any sugar present, the solution will be decolorized. Should there at the same time be any albumin in the sample, it should be removed before the sugar test is applied.

Other tests that may be mentioned, although possessing no advantages over those already given,—in fact, in many instances being far inferior, viz.:—

Sulphur acid (Runge).

Boiling with sodium or potassium hydroxide (Moore).

Acetate of lead and ammonium (Rubner).

Alpha-naphthol and thymol (Molisch).

Chromic acid (Hunefeld).

Picric acid (Johnson).

Pellets containing the component parts of Fehling's solution, and test paper charged with sodium carbonate and indigo carmine, are also employed. Both, however, are unreliable.

QUANTITATIVE DETERMINATION OF GLUCOSE IN URINE.

Either of the two following methods are usually employed:—

Roberts' Fermentation Method.—This depends on the decomposition of the grape sugar, by means of fermentation, into alcohol, carbon dioxide, and other products, with a corresponding decrease in the specific gravity of the urine. Each degree of specific gravity lost by fermentation corresponds to 1 grain of sugar per fluidounce. For example, if a sample of urine possessed the specific gravity of 1.030 before, and 1.020 after fermentation, it would then have contained 10 grains of sugar per fluidounce. The method is as follows: A convenient quantity, say about 4 fluidounces of the sample, is placed in a 12-ounce bottle, and a lump of German yeast (Fleischman's) or about a fluidrachm of baker's yeast is added, then mixed. The bottle is closed with a nicked cork (to allow the escape of gas) and set aside in a warm place (60–77° F.) to ferment. At the same time a sample of four

ounces of the urine is set aside in a tightly stoppered vial. In about 24 hours the fermentation is over, leaving the fluid lighter and reduced in specific gravity in proportion to the quantity of sugar present. The fermented urine is removed and its specific gravity taken; at the same time the unfermented sample is likewise examined and the difference in specific gravity noted. The number of degrees of density lost represent the number of grains of sugar in each fluidounce of the sample of urine. The percentage may be ascertained approximately by multiplying the number of degrees lost by 0.23.

Fehling's Test Solution.—The quantitative estimation of glucose by means of Fehling's solution* may be carried out either gravimetrically or volumetrically.

In the *gravimetric* method a measured volume (50 Cc.) or weighed quantity of the urine diluted with water (1 to 5) is slowly added to an excess (50 Cc. or more) of boiling Fehling's solution, which has been also diluted with about an equal volume of water. After boiling about three minutes, the solution should retain a blue color, showing that there is an excess of the reagent. The red precipitate (copper suboxide) is then collected on a plain filter, great care being observed against loss. The vessel is rinsed out several times with boiling water on to the filter, which is washed continuously (with boiling water) until all traces of the copper solution have been removed. This may be ascertained by testing the filtrate. The precipitate and filter are ignited and weighed while warm. The weight of copper oxide less the filter-ash, multiplied by the factor 0.4535 gives the weight of glucose present.

The *volumetric* method is applied by adding measured quantities of the diluted urine to the boiling standard Fehling's solution until the blue color of the latter disappears, each 10 Cc. of the solution corresponding to 0.05 Gm. of grape sugar. Owing to the instability of Fehling's solution various modifications have been proposed, among which Dr. Pavy's is perhaps the most stable. This standard solution may be made by dissolving 4.742 Gm. of pure copper sulphate in 200 Cc. of distilled water with 38 Cc. of glycerin (C. P.). In another 200 Cc. of distilled water dissolve 23.5 Gm. of potassium hydrate (C. P.). Mix the two solutions, and when cold add 450 Cc. of 28 per cent. aqua ammonia. Finally add sufficient distilled water to make the volume up to exactly 1000 Cc. Of this standard solution 35 Cc. are reduced by 0.02 Gm. of grape sugar. To carry out the assay, 35 Cc. of the standard copper solution are measured into an assay flask, diluted with about two volumes of distilled water and heated to boiling. Into this boiling solution the sample of urine is slowly dropped from a burette, until the blue color begins to disappear; then allow at least five seconds to elapse between each drop, until the test

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* See page 478, or under Volumetric Method.

solution has become colorless. The number of cubic centimeters of urine required is read off, these containing 0 02 Gm. of sugar. On standing a while after the estimation has been concluded this solution will again resume a blue color, due to the absorption of oxygen from the air. This should not be mistaken for incomplete reduction.

FRUIT SUGAR, OR LEVULOSE.

Usually this substance is found in urine associated with grape sugar; rarely does it appear alone. It may be distinguished from grape sugar by the fact that it turns the plane of polarization to the left. Levulose reduces copper salts from their solution, as does grape sugar, although more feebly so. It also forms yellow crystals with phenylhydrazin hydrochloride, these crystals however melting at a temperature of 150° C. It does not melt as readily as grape sugar, nor does it crystallize.

Detection.—Other substances which turn polarized light to the left being excluded, a saccharine urine which deflects polarized light strongly to the left may be said to contain levulose.

LACTOSE, OR MILK SUGAR.

Milk sugar is usually found in the urine of women several days after parturition, and just prior to the appearance of milk in the mammary glands. It crystallizes in white rhombic prisms, which are soluble in six parts of cold water and two and one-half parts of hot water, and insoluble in alcohol or ether. Aqueous solutions possess a dextro-rotatory power of 59.3°, and do not readily undergo alcoholic fermentation. It reduces copper salts in an alkaline solution, its power in this respect being, however, one-third less than that of grape sugar. Upon prolonged boiling with dilute acids it forms galactose, which upon treatment with nitric acid yields mucic acid.

Detection.—If the suspected urine give the characteristic copper reaction, and if it also causes polarized light to be deflected to more than 56° to the right, lactose may be presumed to be present. This may be confirmed by Rubner's test, applied as follows: Treat the urine with an excess of lead acetate, filter, and to the filtrate add ammonium until a permanent precipitate is formed. The fluid next is heated, boiling, however, to be avoided; and if a rose-red color gradually appear, which slowly vanishes on standing, it is evidence of grape sugar. If no such reaction occur, lactose is present.

INOSITE, OR MUSCLE SUGAR.

This sugar has been found in the lungs, liver, kidney, brain, and spleen, and occurs in the urine in a number of pathological conditions.

It crystallizes in colorless, monoclinic prisms, large in size and sometimes grouped in rosettes; soluble in six parts of water at 20° C., insoluble in alcohol or ether. It possesses no rotatory

power over polarized light, nor does it undergo alcoholic fermentation. It does not reduce alkaline copper solutions, but upon boiling with them the liquid assumes a greenish tint, which disappears on standing and again appears upon boiling.

Detection.—(*a*) Evaporate a solution of inosite with a little nitric acid on platinum almost to dryness; moisten the residue with a little ammonium and solution of calcium chloride, and again evaporate to dryness; and notice the bright rose-red or violet color that is produced. This reaction is said to become apparent with even 1 Mg. of inosite. With other sugars the test will be negative.

(*b*) Add to a solution of inosite a little mercuric nitrate solution; a yellow precipitate will be produced. On gentle heating the color turns to red; upon cooling it disappears, but reappears on gently heating. Albumin and grape sugar interfere with this reaction and if present must be removed.

SEPARATION OF INOSITE FROM URINE.

Treat the urine with neutral lead acetate until precipitation ceases, after having first removed any albumin that may be present. Now filter, warm, and treat filtrate with subacetate of lead as long as any precipitate results. Collect this precipitate after twelve hours, wash, suspend in water, and decompose with sulphuretted hydrogen. Upon standing, a little uric acid separates; separate the liquid therefrom by filtration, concentrate by boiling, and while boiling add three or four volumes of alcohol. A heavy precipitate is the result, from which the hot alcoholic solution is poured off, or it may be removed by filtration, through a hot funnel if necessary; the solution now is set aside to cool. Usually in about twenty-four hours crystals of inosite appear; they may be removed by filtration and washed with cold alcohol. If, however, no crystals of inosite have separated, add ether to the clear, cold, alcoholic filtrate until it becomes milky, and set aside in the cold for twenty-four hours, when crystals of inosite will make their appearance.

Glycuronic acid, $C_6H_{10}O_7$, cane sugar, and glycogen may under certain conditions be found present in the urine. Their occurrence is rare, however, and it is only the first one that becomes of interest, from the fact that it is often mistaken for grape sugar, since, like it, it gives a yellow or even red precipitate with cupric oxide, reduces, bismuth, mercury and silver salts, and is dextrorotatory. It may be distinguished from grape sugar by the fact that it does not undergo alcoholic fermentation.

ACETONE, C_3H_6O.

Both acetone and aceto-acetic are probably decomposition products of albumins. Sometimes both are present in the urine, sometimes only one of them. It is claimed by some authorities (v. Jaksch) that acetone in minute quantities is a normal constituent of urine, while others claim that it only occurs in the urine

after ingesting food rich in proteids or after the ingestion of considerable quantities of alcohol.

Acetone is a colorless liquid, specific gravity .792, boiling at 56.5° C., and possessing a peculiar fruit-like or ethereal odor. It may be obtained by distilling the urine of diabetic patients, and has been found in the urine of children apparently in good health.

It forms, when heated with caustic potassium and iodide of potassium, iodoform; when treated with solution of nitroprusside of sodium and ammonium, a rose-red color is produced.

Detection.

(*a*) *Iodoform Test.*—Distill a quantity of suspected urine, and treat the distillate with caustic potassium and potassium iodide, when, if acetone be present, crystals of iodoform will be formed. Ethyl-alcohol and lactic acid, however, produce the same reaction.

(*b*) *Le Noble's Test.*—This is a very delicate test, small quantities being readily detected by it. It may be applied as follows: Add to a dilute alkaline solution of nitroprusside of sodium the suspected urine, when, if acetone be present, a deep-red color is produced, which soon changes to yellow, and on boiling with an acid assumes a greenish-blue or violet tint.

(*c*) *Beyer's Indigo Test.*—Dissolve in the suspected urine a few crystals of nitrobenzaldehyde with the aid of heat; on cooling the mixture aldehyde separates in the form of a white cloud. The mixture is now made alkaline with dilute sodium solution, when, if acetone be present, it assumes at first a yellow, then a green, and lastly an indigo-blue color within a short time.

(*d*) *Chautard's Test.*—Fluids containing over 0.01 per cent. of acetone, when treated with a drop of aqueous solution of magenta decolorized by sulphurous acid, give a violet color. If the solutions be very dilute, four or five minutes will elapse before the reaction becomes apparent.

(*e*) *Reynold's Test.*—This test may be applied as follows: To some freshly precipitated yellow oxide of mercury is added a small quantity of urine, the mixture shaken and filtered. A solution of ammonium sulphate is next added to the clear filtrate, and if acetone be present, some of the mercuric oxide is dissolved, and a black ring of sulphide of mercury will appear at the point of contact between the two liquids. The test depends on the fact that acetone possesses the power of promoting the solution of mercuric oxide.

DIACETIC OR ETHYLACETIC ACID ($C_6H_{10}O_3$).

This is a strongly acid liquid, colorless, and mixes with water, alcohol, and ether in all proportions. Upon heating with acids it decomposes into acetone and carbon dioxide. With solutions of ferric chloride it gives a violet-red or brownish-red color, thus differing from acetone. If the solution be boiled this color rapidly pales, differing in this respect from phenol, acetic acid, salicylic acid, and sulphocyanide.

Detection.—V. Jaksch's method is probably best adapted for its detection. Add to a recently voided specimen of urine a few drops of ferric chloride; if phosphates be precipitated, filter, and to the clear filtrate add a few drops more of ferric chloride solution. If a red color be produced, boil a portion of the urine, and to another portion add a few drops of sulphuric acid and shake with ether. If the red color grows pale in the ethereal extract after 24 hours, and appears but slightly or not at all in the boiled portion, and if considerable acetone be detected upon distillation, diacetic acid is presumably present.

BILIARY ACIDS.

There is much discussion and a great difference of opinion regarding the presence of biliary acids in the urine, under physiological conditions. Recent researches, with new and delicate methods of testing for these acids, would make it appear, however, that they are present in normal urine in very minute quantities. The quantity of biliary acids present in normal urine is estimated by Dr. Oliver as about one part in from 10,000 to 15,000 parts.

Detection.

(*a*) *Oliver's Method.*—In this method an acid solution of peptone is employed, prepared after the following formula: Pulverized peptone ʒss; salicylic acid 4 grains; acetic acid ʒss; distilled water enough to make 8 ounces; filter repeatedly until perfectly clear. The urine to be tested must be made acid, if not already so, and its specific gravity reduced to 1.008, if it be above that figure. To ʒj of test solution 20 minims of urine are added, and if bile acids are present in normal amount, no immediate reaction occurs, but shortly a slight milkiness becomes visible. If the bile acids be in excess, a distinct milkiness at once becomes visible, its intensity depending on the quantity of bile acid present. On agitation the opalescence diminishes or may disappear, but upon addition of more test solution it again appears. This test is most sensitive and simple, and depends upon the fact that such products of gastric digestion as peptone and propeptone are precipitated in the duodenum by contact with bile acids.

(*b*) *Pettenkofer's Test.*—Mix the suspected urine with concentrated sulphuric acid, not allowing the temperature to rise above 60° to 70° C. Next add a 10 per cent. solution of cane sugar, drop by drop, constantly stirring the mixture. If bile acids be present the liquid assumes a beautiful red color, not disappearing at ordinary temperatures, but changing to a bluish-violet in the course of time. This red liquid shows a spectrum with two absorption bands, the one at F, and the other between D and E, near E.

Other substances, such as albumin, oleic acid, amyl-alcohol, and morphine give a similar reaction, so, in doubtful cases, it is necessary to apply the spectroscopic test.

Too much cane sugar must not be added, otherwise the mixture assumes a black color. Care must be taken that the temperature does not rise above 70° C., and that the sulphuric acid employed is chemically pure.

BILIARY PIGMENTS.

The coloring matters of bile appear in urine in a number of pathological conditions. They impart to the urine abnormal colors,—yellowish-brown, deep brown, greenish-yellow, greenish-brown, and at times green. If a sediment be present in such urine it often assumes the color of the bile pigment. Urine containing bile pigments, upon shaking, becomes frothy, the bubbles having a yellow or yellowish-green color.

Detection.

(*a*) *Gmelin's Test.*—Place a quantity of urine in a test-tube, and allow a small quantity of strong nitric acid, containing a little nitrous acid, to pass carefully down the sides of the tube, so that it underlies the urine. If biliary coloring matters are present, at the point of union between the two liquids will very soon be seen from below upward the colors green, blue, violet, red, and yellow. The green always predominates, while the blue is often indistinct and may be absent.

Rosenbach's Modification.—Filter the urine through a fine, thick filter, and apply after filtration a drop of nitrous acid to the inside of the filter. A pale spot will be noticed, surrounded by colored rings, which appear yellow, red, violet, blue, and green.

Dragendorff's Modification.—Place a little urine on a plaster-of-Paris disc, and; when nearly absorbed, a drop of acid is allowed to fall on the moistened spot. If the pigments are present, a ring of colors forms around the acid drop, the green predominating.

(*b*) *Huppert's Test.*—This is a very delicate test, and by it the minutest trace of bile pigment may be detected.

Treat the suspected urine first with lime-water, or some chloride of calcium solution, and then with a solution of sodium or ammonium carbonate. The precipitate, consisting of bile pigments, may be removed by shaking with chloroform, after washing with water and after acidulating with acetic acid. The bilirubin is taken up by the chloroform and colors it yellow, while the acetic acid solution is colored green by bilirubin.

(*c*) *Ultzmann's Test.*—Add to about 10 Cc. of suspected urine 3 or 4 Cc. of a strong caustic potash solution, and then add hydrochloric acid. If bile pigments be present, the liquid will assume a beautiful green color.

INDOXYL-SULPHURIC ACID ($C_8H_7NSO_4$).

Indoxyl-sulphuric acid is derived from indol, a substance formed in the system by the decomposition of proteid bodies. Indol is oxidized into indoxyl, and this united with sulphuric acid forms indoxyl-sulphuric acid. It occurs in the normal urine

as a potassium salt, is known as urine indican, and formerly was improperly named uroxanthin.

Detection. (*a*) *Jaffe's Method.*—Mix 10 Cc. of strong hydrochloric acid with an equal volume of urine in a test-tube; mix thoroughly and add, drop by drop, a fresh saturated solution of chloride of lime or chlorine water until a deep blue color is obtained. If chloroform be now added to the mixture, it readily holds the indican in solution, and depending upon the depth of color of the chloroformic solution, the quantity of indican present may be approximately estimated. If albumin be present it must first be removed, otherwise the blue color produced in a mixture containing albumin and hydrochloric acid may prove a source of error. Small quantities of indican are destroyed, however, by chloride of lime, thus rendering the test negative, unless indican be present in considerable quantity.

(*b*) *MacMunn's Method.*—Boil together equal parts of urine and hydrochloric acid, with a few drops of nitric acid, cool, and agitate with chloroform. If much indican be present the chloroform assumes a violet color, and shows an absorption band before D, due to indigo blue, and another after D, due to indigo red. An approximate estimation may be based upon this method as follows: To 4 Cc. of hydrochloric acid contained in a flask, add, while stirring, from 10 to 20 drops of urine. If the quantity of indican be normal, the color that results will be light yellow; if in excess, the color will become violet or blue. If the coloration does not appear in a few minutes, indican is not in excess, however deep the color that subsequently appears may be.

β-OXYBUTYRIC ACID ($C_4H_8O_3$).

This acid is found especially in the urine in severe or chronic cases of diabetes mellitus. It is usually accompanied by diacetic acid and sometimes by acetone. Oxybutyric acid is readily miscible with water, alcohol, and ether, and occurs as an odorless, syrupy liquid. It strongly deviates polarized light to the right, and therefore, if present, interferes with the estimation of sugar by polarimetry. Upon oxidation it yields acetone, and on boiling with water in the presence of a mineral acid it decomposes into α-crotonic acid and water. Lead acetate does not precipitate it.

Detection. (*a*) *Kulz's Method.*—Evaporate the fermented urine to a syrupy consistence, add an equal volume of strong sulphuric acid, and distil without allowing the mixture to cool; α-crotonic acid is produced; this is distilled off, cooled, and allowed to crystallize, the crystals having a melting point of 172° C.

(*b*) If after fermentation a suspected urine still exhibit dextro-rotatory properties, it may be assumed that hydro-oxybutyric acid is present.

Ehrlich's, or the Diazo Test.—Ehrlich, in 1882, first suggested this test, as a valuable diagnostic agent in typhoid fever.

The test depends upon the fact that if sulphanilic acid be acted upon by nitrous acid, diazosulphobenzol is formed, which forms aniline colors by uniting with certain aromatic substances at times found in the urine.

Diazosulphobenzol may be obtained in a perfectly fresh condition by the following process:—

Prepare (*a*) a solution of 2 Gm. of sulphanilic acid in 50 Cc. of hydrochloric acid, adding when dissolved 1000 Cc. of distilled water.

(*b*) A 0.5 per cent. solution of sodium nitrite.

When these solutions are brought together nitrous acid is formed, and this, acting on the sulphanilic acid, forms diazosulphobenzol. The test is performed as follows:—

Take of solution (*a*) 50 parts, and of solution (*b*) one part, mix them, and place equal parts of this solution and of urine in a test-tube, and make alkaline with ammonia. If a reaction occur, the solution assumes a carmine-red color, which color must also appear in the foam if the mixture be shaken. Upon standing for twenty-four hours a greenish precipitate forms.

Ehrlich originally claimed for the diazo reaction the following:—

(*a*) The reaction is most commonly found in typhoid fever, from the fourth to the seventh day and thereafter, and if the reaction be absent the diagnosis is doubtful.

(*b*) Cases of typhoid fever characterized by faint reaction and occurring only for a short time may be predicted to be of very mild type.

(*c*) The reaction is occasionally noted in phthisis pulmonalis, but only in cases pursuing a rapid course toward a fatal termination.

(*d*) The reaction is sometimes, but not often, observed in cases of measles, miliary tuberculosis, pyæmia, scarlet fever, and erysipelas.

(*e*) In diseases unaccompanied by fever, as chlorosis, hydræmia, diabetes, diseases of the brain, spinal cord, liver, and kidneys, the reaction is always absent.

GLOBULINURIA.

Associated with albuminuria, in nearly all cases we find globulinuria. Although the quantity of globulin in the blood is relatively smaller than that of albumin, being as 1 is to 1.5, we often find the quantity of globulin in an albuminous urine exceed the quantity of albumin. The fact that globulin is more diffusible than albumin may account for this proportional excess. It owes its appearance in the urine to the same causes as does albumin, and its clinical significance is therefore the same. It is found in especial large quantities in catarrhal cystitis, in acute nephritis, and in amyloid degeneration of the kidneys. In chronic Bright's

Disease it is usually only present in small quantities. Globulin is insoluble in water, but dissolves in dilute neutral saline solutions, or in water containing very little acid or alkali, but upon neutralizing the solvent it reprecipitates. Neutral saline solutions of globulin are precipitated on saturation with sodium chloride or magnesium sulphate.

PROTEOSES.

These substances are formed artificially by heating albumin with water, and more readily by heating with dilute mineral acids. They are formed in the body by the action of the gastric and pancreatic juices, and may be considered as the intermediate products in the hydration of proteids, the final products being peptones. Propeptone as described by Schmidt-Mulheim and the α-peptone of Meissner are identical with these substances. They cannot be coagulated by heat nor by alcohol, but are precipitated by the latter. Nitric acid precipitates them, the precipitate being dissolved by heat but reappears upon cooling, and they all respond to the biuret reaction. Depending upon the proteid from which they are derived, they may be subdivided into albumoses, globuloses, vitelloses, caseoses, myosenoses, etc.

ALBUMOSURIA.

According to their solubility these substances have been classed as follows:—

(*a*) *Proto-Albumose.*—Soluble in cold and hot water and saline solutions. Precipitated by saturation with sodium chloride and magnesium sulphate.

(*b*) *Hetero-Albumose.*—Insoluble in water, soluble in cold 0.5 to 15 per cent. sodium chloride solutions; heating this solution to 65° C. causes a precipitate soluble in dilute acid or alkali.

(*c*) *Deutero-Albumose.*—Soluble in cold and hot water. It is not precipitated from its solutions by either sodium chloride or magnesium sulphate. Strong solutions of ammonium sulphate precipitate it. Copper sulphate does not precipitate it, and nitric acid only precipitates it in the presence of excess of saline.

Two varieties of albumoses exist; hemi-albumoses, which by further action of the digestive juices are converted into hemipeptones, and anti-albumoses, which by like action are converted into anti-peptones.

PEPTONURIA.

Peptones are the final products, resulting from the action of the gastric and pancreatic juices. They may be divided into two classes.

(*a*) Hemipeptone, which is split up into leucin and tyrosin by further action of the pancreatic juice.

(*b*) Antipeptone, upon which the further action of pancreatic juice gives a negative result.

Peptones are also the result of retrogressive changes in albuminoids, and of the solid constituents of the blood, and are met with in conditions causing such changes.

Peptones dissolve in water, and heat does not coagulate them. Nitric acid, copper sulphate, potassium ferrocyanide, ammonium sulphate, do not precipitate peptones. They are precipitated by tannic acid, picric acid, potassio-mercuric iodide, phosphomolybdic acid, and phosphotungstic acid. Both hemi- and antipeptone diffuse readily through animal membrane.

Detection in Urine.—Saturate the urine, after first slightly acidifying with acetic acid, with ammonium sulphate, and filter out any resulting precipitate, which may consist of albumin, globulin, proto-albumose, hetero-albumose, or deutero-albumose. Now the addition of any precipitant of peptone, such as picric acid, or potassio-mercuric iodide, will throw down peptone if it be present.

DIFFERENTIATION BETWEEN PEPTONE AND DEUTERO-ALBUMOSE.
(*Halliburton.*)

Peptone.	*Deutero-albumose.*
1. Gives no precipitate with nitric acid.	1. Gives no precipitate with nitric acid unless a considerable amount of salt be added. This precipitate dissolves on heating and reappears on cooling.
2. Is not precipitated by saturation with ammonium sulphate.	2. Is precipitated by saturation with ammonium sulphate.

Kuhn has shown that the ammonium sulphate should be added to the boiling solution, and the operation repeated until no further precipitate occurs. In this way only is it possible to effect a complete separation of the albuminoses from peptones.

Halliburton's table, showing the reactions of the several proteids, with various reagents, will be found of value. (See p. 492.)

FIBRINURIA.

The presence of this substance in the urine is responsible for the phenomena of coagulation, which is sometimes observed in urine upon standing. Its presence is due to various pathological conditions. It is, when fresh, a white, tenacious mass, but upon drying it assumes a gray color. Fibrine is insoluble in water and the hydrocarbons. It is feebly soluble in neutral saline solutions, heat assisting the solution. Treated with caustic alkalies or dilute hydrochloric acid it swells and forms a gelatinous mass. With stronger acids a solution takes place with the formation of albumoses and acid albumin (syntonin). Pepsin in an acid solution, and trypsin in an alkaline solution act readily on fibrin, forming primarily globulin, and secondarily, albumoses and peptones.

Variety of Proteid.	Hot and Cold Water.	Hot and Cold Saline Solution, *e. g.*, 10 % NaCl.	Saturation with NaCl or $MgSO_4$.	Saturation with $(NH_4)_2SO_4$.	Nitric Acid.	Copper Sulphate.	Copper Sulphate and Ammonia.	Copper Sulphate and Caustic Soda or Potash.
Albumins.	Soluble in cold and coagulated in hot water.	Soluble in cold and coagulated in hot solutions.	Not precipitated.	Precipitated.	Precipitated in cold; not dissolved by heating.	Precipitated.	Blue solution.	Violet solution.
Globulin.	Not soluble in either.	The same as albumins.	Precipitated.	Precipitated.	The same as albumins.			
Proteo-albumose.	Soluble in both.	Soluble in both.	Precipitated.	Precipitated.	Precipitated in cold; precipitate dissolves in heat and returns in cold.	Precipitated.	Violet solution.	Rose-red solution.
Hetero-albumose.	Insoluble, *i. e.*, like globulins precipitated by dialysis from saline solutions.	Soluble in both; partly precipitated but not coagulated by heat to 65° C.	Precipitated.	Precipitated.	"	"	"	"
Deutero-albumose.	Soluble.	Soluble.	Not precipitated.	Precipitated.			"	"
Peptone.	Soluble.	Soluble.	Not precipitated.	Not precipitated.	Not precipitated.	Not precipitated.	"	"

Detection.—(*a*) Separate the coagulated mass by filtration and wash with water. The addition of a one per cent. solution of hydrochloric acid will cause it to swell, and if pepsin now be added, a complete solution is effected.

(*b*) Treat the washed coagulum with a dilute solution of sodium hydrate; if after prolonged contact no solution takes place, the substance is presumably fibrine, albuminous bodies being soluble in this reagent.

(*c*) Treat the washed coagulum with a one per cent. solution of sodium carbonate, employing a gentle heat for several hours, when a complete solution will be effected. Filter, and treat with Millon's reagent, which causes a deep red color to appear.

MUCINURIA.

It is highly probable that the term mucin may be applied to various bodies derived from different sources. All mucins, however, possess certain characteristics, viz., they are not coagulated by heat, soluble in strong mineral acids and alkalies. Dilute mineral acids, strong alcohol and organic acids precipitate them. Normal urine contains minute quantities of mucin which is derived from the mucus found in all urine. It only becomes of importance when the quantity found is in excess of the normal amount, and in this case it is often a source of error, in testing for small quantities of albumin. (See Albumin.)

Detection.—Dilute the urine with water; this diminishes the solubility of the mucin by the sodium chloride of the urine, and also prevents the precipitation of uric acid on the subsequent addition of acid. Now if an excess of acetic acid be added, mucin is precipitated. It may be purified by dissolving in an alkaline solution and reprecipitating with acetic acid.

HÆMOGLOBINURIA.

The pigment of the blood, hæmoglobin, is sometimes found in the urine, independent of the corpuscular elements of the blood. It is a crystalline substance, but is non-diffusible, and gives the proteid reaction. This substance has the property of absorbing oxygen, and exists in the blood in two conditions—when charged with oxygen, as in arterial blood, it is known as oxyhæmoglobin, and when deprived of oxygen, as in venous blood, it is called deoxygenated hæmoglobin.

Detection.—(*a*) By spectroscopic examination, showing its characteristic bands.

(*b*) *Guaiacum Test.*—Equal volumes of tincture of guaiacum and ozonized turpentine are mixed in a test-tube. Add the urine, and if it contains hæmoglobin a blue ring will appear at the point where the two liquids come in contact. On shaking, the entire mixture becomes blue. Pus also gives a blue color with these reagents, but the blue color is imparted only to the tincture

of guaiacum; furthermore, it disappears entirely if the urine be heated to the boiling-point.

URINARY SEDIMENTS OR DEPOSITS.

Numerous attempts have been made to classify sediments. Some classifications being based on the appearance of these deposits to the naked eye, others classifying them with regard to their origin and nature, whether crystalline or amorphous, organized or unorganized. For purposes of study it is most convenient to classify them, as Purdy does, into two divisions, viz., *chemical* and *anatomical* deposits.

The principal *chemical sediments* found in the urine are as follows: Uric acid, various urates, calcium oxalate, cystin, leucin, tyrosin, xanthin, and phosphates. With few exceptions they are in solution in normal urine, and become deposited as the result of an excessive secretion or excretion, or as the result of changes in the urine, causing their separation, by lessening its solvent power. They occur either as crystalline or amorphous deposits.

The chief *anatomical sediments* consist of such structures as pus, blood, epithelial cells, renal casts, spermatozoa, portions of morbid growths, fungi, infusoria, and entozoa. They do not exist in normal urine, and being more or less insoluble in urine, they separate out on standing.

METHODS OF OBTAINING SEDIMENTS.

The old method of allowing the urine to stand in a conical vessel for 24 hours, and thus obtaining these deposits by gravitation, is necessarily tedious, and in many cases leads to error, since the time needed to obtain such sediments often allowed alteration in the urine. Preservative agents, such as chloral, salicylic acid, and resorcin have been added to overcome this difficulty, but, as might be supposed, they often interfere with the subsequent chemical examination of the urine.

Recently the centrifugal method of obtaining urinary sediments for purposes of examination has been shown to possess great advantages over the older method. When urine is placed in a tube, and made to revolve rapidly, a centrifugal force is exerted upon all the solid particles it may contain, many times greater than gravity. In consequence of this the solid particles are almost immediately deposited at the bottom of the test-tube, without regard to the specific gravity of the urine.

The principal advantages of this method are stated admirably by Purdy, as follows:—

(*a*) Centrifugal sedimentation of urine permits of an immediate microscopical examination, instead of waiting for from twelve to twenty-four hours by the old method of gravity.

(*b*) The centrifugal method secures more complete and concen-

trated sedimentation, and therefore it is better suited for microscopical diagnosis.

(*c*) Microscopical examination may be made of freshly-voided urine before casts or morphological elements have had time to undergo maceration or solution in the urine, and before bacterial fermentation occurs, which always greatly obscures the microscopical field.

(*d*) It affords the only positive means of distinguishing between normal and abnormal crystalline sediments in the urine because by the centrifugal method only can the urine be examined by the microscope as soon as voided, and, therefore, before the crystals form which are deposited in all normal urines after standing.

(*e*) By the old method of gravity it sometimes happened, with urines of high specific gravity, that the lighter casts (such as those of the narrow hyaline order) failed to settle and thus eluded detection. The centrifugal precipitates all casts without delay, irrespective of the above named conditions.

(*f*) In consequence of the greater concentration of the urinary sediments by the centrifuge, bacterial search is rendered more simple and successful, micro-organisms, such as tubercle bacilli, being found with greater ease and certainty.

Fig. 404.

Purdy's Electric Centrifuge. (One-fourth actual size.)

Fig. 405.

Purdy's Sediment Tubes for Centrifugal Sedimentation. (Full size.)

Various forms of the centrifuge may be had at the instrument dealers. They may be operated by hand or electric power.

Two chief methods are employed in the examination of urinary sediments, viz.: chemical and microscopical.

Chemical deposits can usually be identified by their chemical reactions, or when crystalline the microscope may be used to identify them.

The character of an anatomical deposit is usually determined by the microscope; in rarer instances only does chemistry aid us.

Normal urine being a very unstable fluid, it is of the utmost importance that in searching for sediments, a freshly voided specimen be used. Certain changes occur in all urine upon standing, in consequence of which deposits occur.

Strictly normal, freshly voided urine, of acid reaction, is transparent and contains no sediment whatever. After standing a short time, faint flocculi of mucus, entangling mucous corpuscles, and epithelial cells appear. Upon longer standing, other deposits occur, viz., first a reddish-yellow deposit of amorphous urates, mainly potassium, sodium, and ammonium urates, rarely calcium and magnesium urates; this sediment readily dissolves upon the application of heat. After this, the sediment is partially replaced by the characteristic crystals of uric acid, among which a number of calcium oxalate crystals are usually found. Still later, a sediment composed of the alkaline earth phosphates may deposit from strictly normal urine.

In strictly normal urine of alkaline reaction, such as may be passed three or four hours after meals, or early in the morning, sedimentation often occurs. This sediment is composed of earthy phosphates, and it promptly disappears upon the addition of an acid.

The presence of extraneous substances in the urine often is a source of error. The most common among these substances are, fibres of cotton and linen, hair, wood fibre, starch granules, oil globules, etc.; the student should be familiar with the microscopical appearances of these before attempting the examination of sediments.

Scratches and marks in the glass slides, also are a source of much confusion at times, being often mistaken for casts. Indeed, these markings were for a long time described by different observers as pigment flakes.

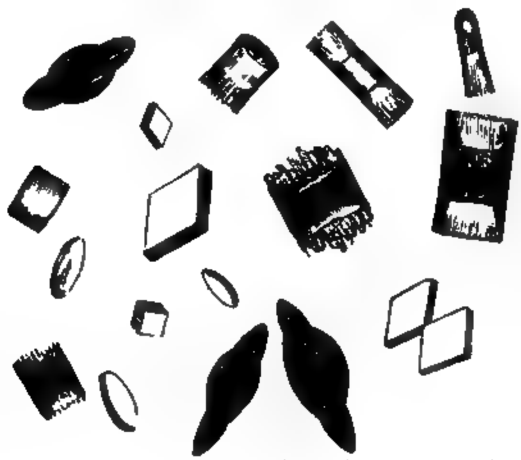
CHEMICAL SEDIMENTS.

Uric Acid.

The nature of this sediment is readily distinguished by the naked eye. It is the only deposit having a deep yellow or orange-red color that is liable to occur in urine, and its crystalline character is readily detected. The crystals of uric acid occur in a great variety of forms, all, however, being modifications of its essential form, the rhombic prism. These crystals are often found adherent to the sides of the vessel containing the urine, or to any foreign material, such as threads, etc., which may be present in such

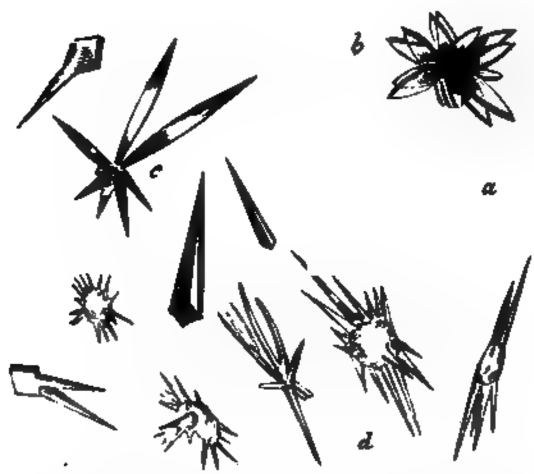
urine. This tendency to crystallize upon or around foreign bodies explains why nearly 70 per cent. of the vesical calculi are composed entirely or at least partially of this substance. For tests see—

FIG. 406.



More Usual Forms of Uric Acid Crystals. (*After Harley.*)

FIG. 407.



More Unusual Forms of Uric Acid Crystals. (*After Harley.*)

Uric acid rarely deposits in other than acid urine, and, as has been shown, such deposit occurs in perfectly normal urine after standing for some time. The sedimentation can only be regarded as of pathological significance if it occurs very soon after the urine is voided.

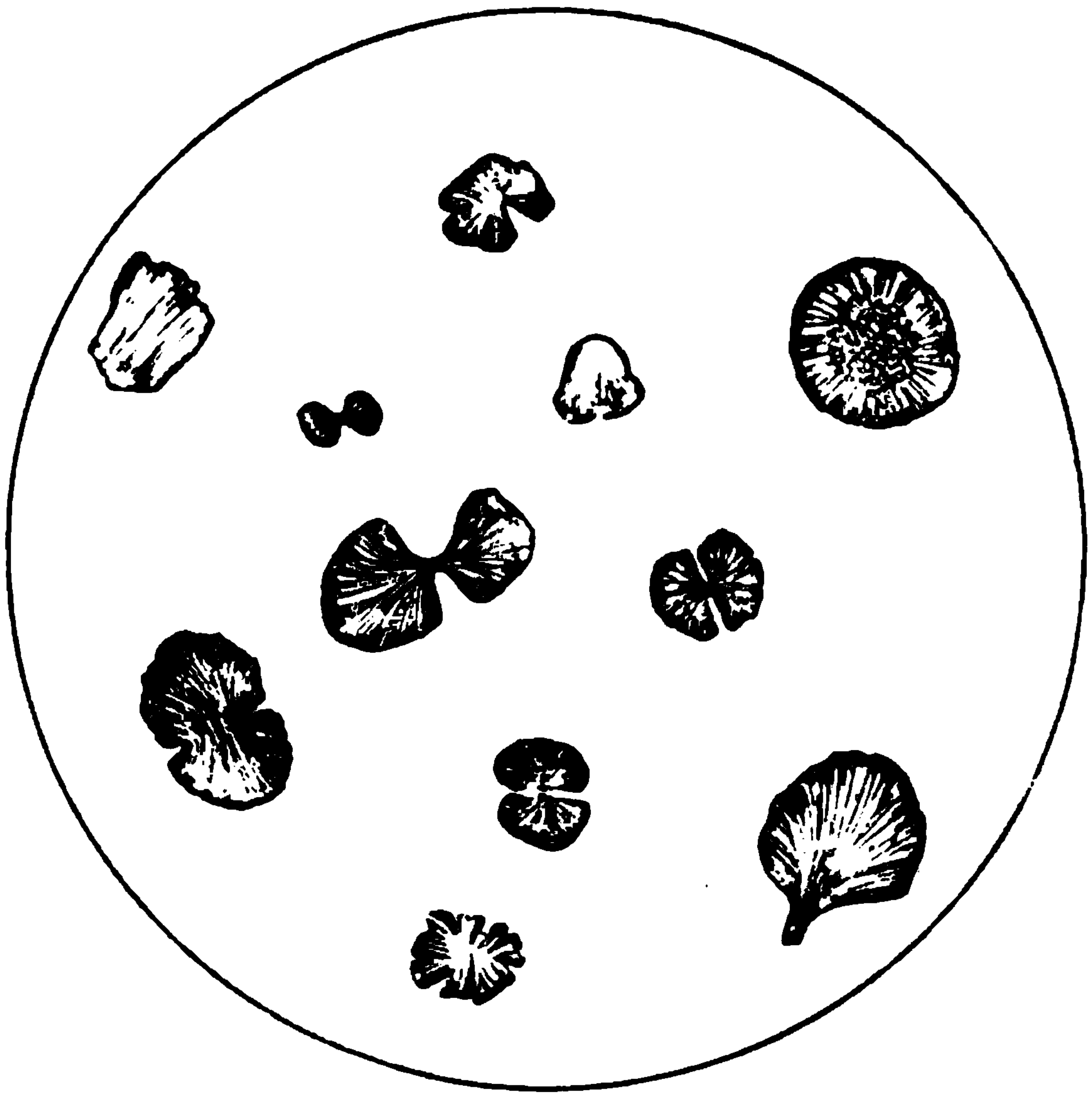
URATES.

(*a*) *Sodium Urate* (*Acid*) forms the chief part of the heavy, usually high colored, and generally bulky deposit of the mixed urates, known popularly as "brick-dust" deposit, that occurs in acid urine. It is found mainly as amorphous granules; rarely does it assume a crystalline form. It is very insoluble, requiring 1100 parts of cold or 125 parts of hot water to dissolve it.

(*b*) *Potassium Urate* (*Acid*) occurs under the same conditions as sodium urate. Unlike the latter, however, it is never crystalline. It dissolves more readily, and is a component part of "brick-dust" deposit.

(*c*) *Calcium Urate* (*Acid*).—This substance rarely occurs as a deposit, either alone or as a part of the mixed urates. It is amorphous, very insoluble, white or gray, and after incineration leaves a residue of calcium carbonate. It is, like the other urates, deposited from acid urine only.

FIG. 408.



Sodium Urate Crystals. (*After Peyer.*)

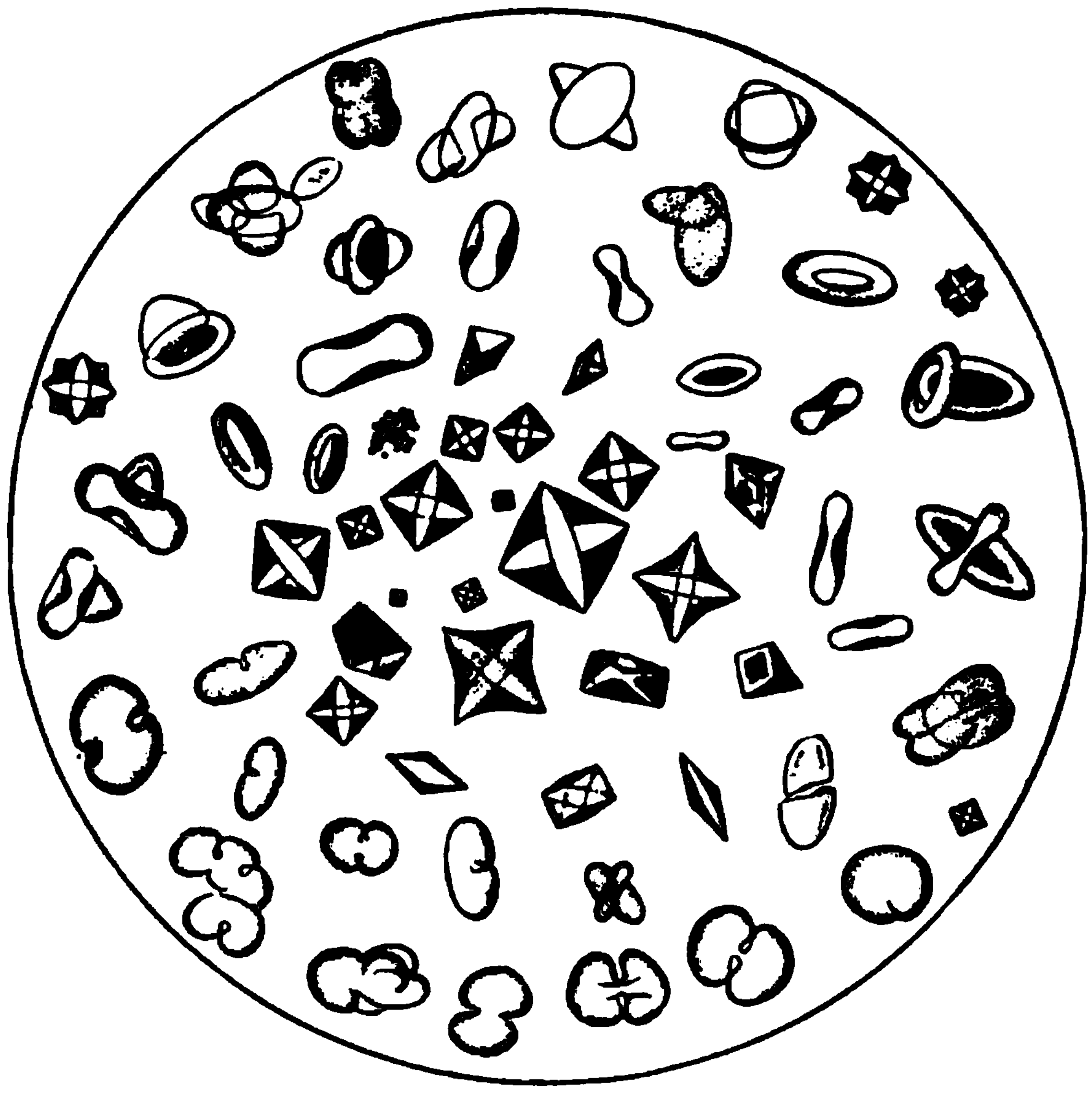
(*d*) *Ammonium Urate.*—This urate is the only one found deposited in urine having an alkaline reaction, and is usually associated with amorphous, earthy phosphates and crystals of triple phosphate. It is a crystalline deposit, dark brown in color, spherical, the spherical masses being studded with fine spicula, from which fact they derive the name "thorn-apple" crystals. These crystals are soluble in hot water and in acids, the latter decomposing them with separation of uric acid. They give the murexid reaction with ammonium and nitric acid.

(*e*) *Mixed Urate Deposit.*—This deposit is known as "brick-dust" sediment, and consists mainly of the acid urate of sodium. In color it varies from a faint pink to a dark red, the color usually being deeper than that of the urine from which it separates. Heat dissolves it readily, thus enabling prompt recognition.

Oxalate of Calcium.

A deposit of oxalate of calcium crystals may occur in either an acid or alkaline urine, more often, however, in the former. If found in acid urine they are often associated with crystals of uric acid, in alkaline urine they occur together with the crystals of triple phosphate. The crystals assume two characteristic forms, the *octohedra* and the *dumb-bell* crystals. The octohedra crystals are

Fig. 409.



Various forms of Calcium-Oxalate Crystals. (*After Peyer.*)

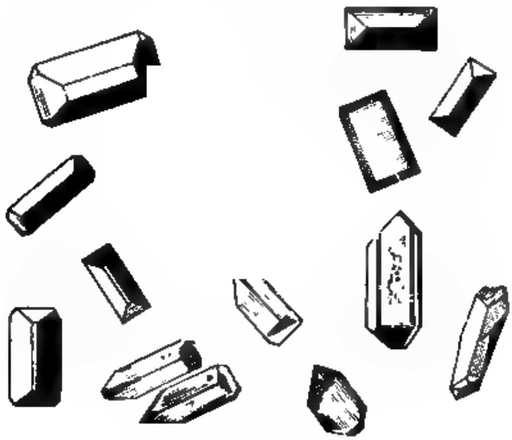
composed of two four-sided pyramids, and when viewed in the long diameter present this appearance, but when seen in their opposite diameter, they present the appearance of a square, crossed obliquely by two bright lines; if the crystals be small, these lines appear as a bright spot in the centre. The *dumb-bell* variety is not so frequently met with, but its appearance under the microscope is characteristic.

Calcium oxalate is not soluble in alcohol, ether, water, acetic acid, or alkaline solutions; it is dissolved readily by mineral acids. It may be identified by its behavior toward solvents, but in practice the microscope is employed to distinguish it from other crystalline deposits.

EARTHY PHOSPHATES.

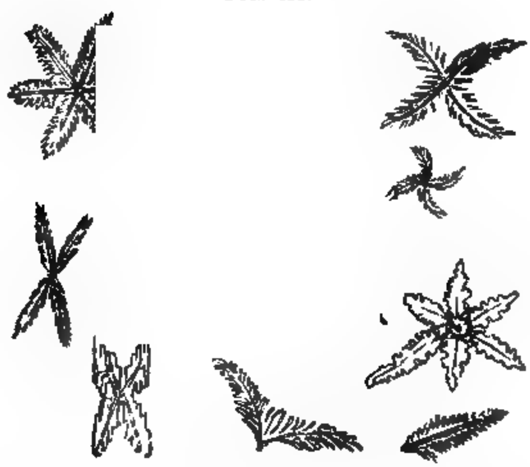
Although phosphoric acid exists in normal urine in combination with alkalies and alkaline earths, the latter combinations are the only ones met with as urinary sediments. These sediments are found chiefly in alkaline, rarely in feebly acid, and never in

FIG. 410.



Triple Phosphate Crystals. (*After Harley.*)

FIG. 411.



Triple Phosphate Crystals. (*After Harley.*)

strongly acid urine. In the advanced state of ammoniacal decomposition they are especially abundant as triple phosphate. They appear as a bulky, white deposit, often rendering the entire urine turbid. We distinguish two varieties of earthy phosphates

in the urine, viz.: *a*, ammonio-magnesium or triple phosphate, and *b*, calcium phosphate, often called phosphate of lime.

(*a*) Ammonio-magnesium phosphate ($MgNH_4PO_4 6H_2O$), or triple phosphate, occurs as a crystalline deposit, of which the typical form is a prism, triangular in form, with beveled ends. Another but less frequent form in which this phosphate appears as a urinary deposit, is that of feathery, star-shaped crystals. Numerous other forms intermediate between the ones described are met with.

(*b*) Calcium phosphate appears as a urinary sediment in two forms, (*a*) amorphous, $Ca_3(PO_4)_2$; (*b*) crystalline ($CaHPO_4$). The amorphous form is the more frequent, and is often mistaken for

FIG. 412.

Crystalline and Amorphous Phosphate of Lime.

pus or other organic matter at first sight. Heat causes it to precipitate from urine, and thus it is often mistaken for albumin.

The crystalline deposit of calcium phosphate is of rare occurrence. These crystals have a wedge-shaped or even conical form, often grouped in stellar or rosette form.

LEUCIN AND TYROSIN.

Leucin ($C_6H_{13}NO_2$) and tyrosin ($C_9H_{11}NO_3$) are both crystalline deposits, are closely related, are nearly always found associated with each other, and are both products of decomposition of proteid bodies.

Leucin occurs as a urinary deposit, in the shape of yellowish, highly refracting spheres, which are often mistaken for oil globules; however, they do not refract light quite as strongly as

globules of oil. These spherules exhibit a tendency to aggregate, appearing to merge into one another where their edges meet.

Leucin is insoluble in ether, also in mineral acids; it is partly soluble in water and alcohol, and completely so in caustic alkalies.

Tyrosin is found in the form of fine needles arranged in tufts or "sheaf"-like collections. If it be crystallized from an alkaline solution, the crystals often assume a rosette shape. It is odorless and tasteless, and has, when it occurs in masses, a white color. Alcohol and ether do not dissolve it; in cold water it dissolves sparingly, but in mineral acids, alkalies, and hot water it dissolves freely.

Chemical Tests.—

(A) *Leucin.*—(*a*) When heated with protonitrate of mercury it separates metallic mercury from this compound. (Hoffmeister.)

FIG. 413.

c

a

Leucin Spheres and Tyrosin Needles.

a, *a*. Leucin balls. *b*, *b*. Tyrosin sheaves. *c*. Double balls of ammonium urate.

(*b*) Fused with nitric acid on platinum foil it leaves a colorless residue, which if heated with caustic potassium forms drops of an oil-like fluid which do not adhere to the platinum. (Scherer.)

(B) *Tyrosin.*—(*a*) *Hoffmann's Test.*—When heated with Millon's reagent, solutions of tyrosin yield a brilliant crimson or pink coloration, which, if much tyrosin be present, is accompanied by a similarly colored precipitate.

(*b*) *Piria's Test.*—If tyrosin be moistened on a watch-glass with concentrated sulphuric acid and warmed for five or ten minutes on a water-bath, it turns pink, owing to the formation of tyrosin-sulphonic acid. This is then diluted with water, warmed, neutralized with barium carbonate and filtered while hot. The filtrate yields a violet color on the careful addition of very dilute per-

chloride of iron. The color is readily destroyed by an excess of the iron salt.

CYSTIN ($C_3H_6NSO_2$).

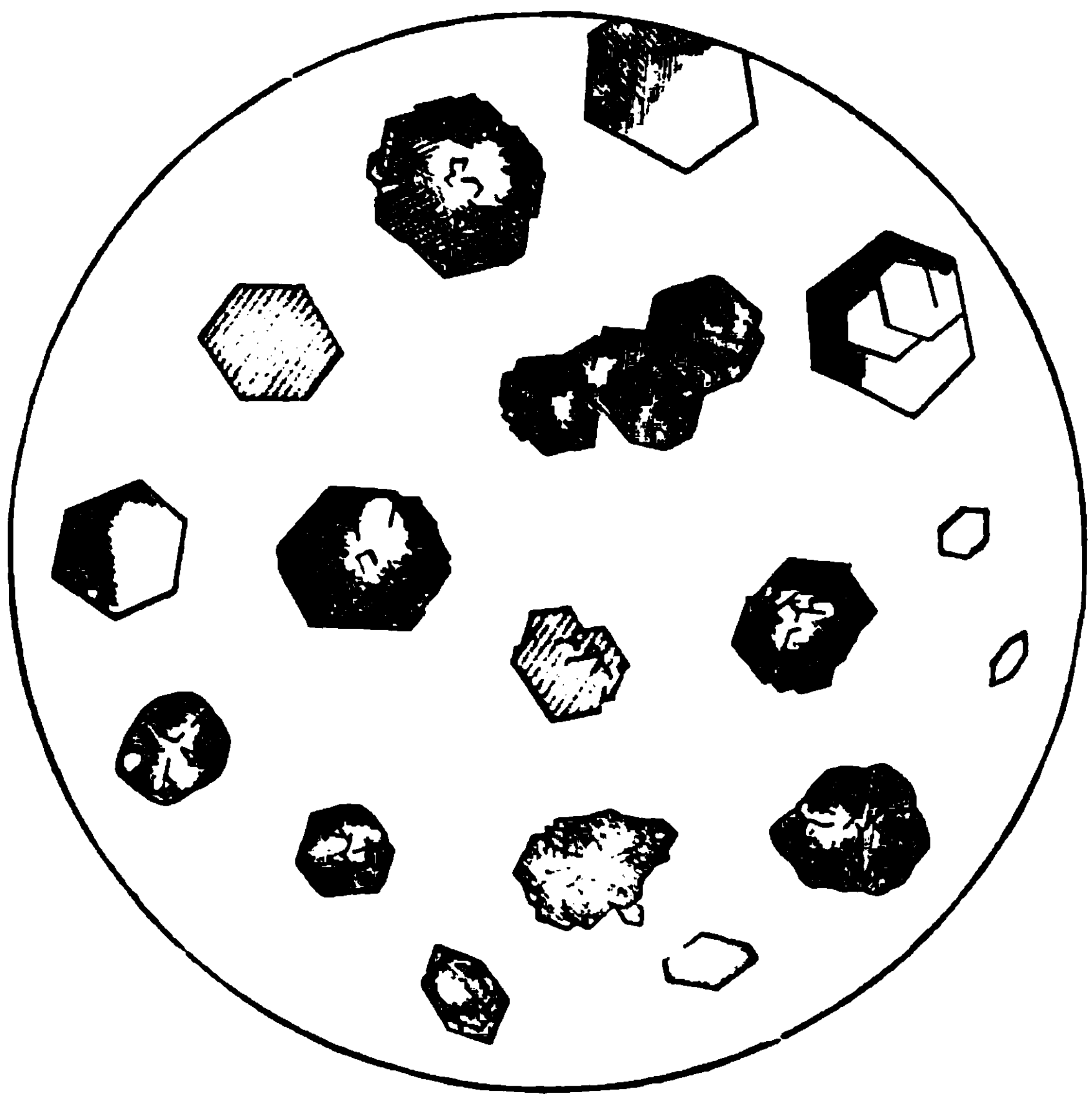
Cystin occurs rarely as a urinary deposit. It is a crystalline body, of a whitish or dirty yellowish-gray color. Under the microscope it may be studied in two forms:—

(*a*) Most commonly as six-sided tablets, variable in size, and bearing some resemblance to the six-sided crystals of uric acid.

(*b*) The second form in which it occurs is that of four-sided square prisms, which either lie separately or are clustered together, often in stellate form.

Cystin is insoluble in hot water, alcohol, ether, or acetic acid; it is soluble in caustic alkalies, oxalic and strong mineral acids. It contains about 26 per cent. of sulphur.

FIG. 414.



The More Common Form of Cystin Crystals. (*After Peyer.*)

Means of Differentiating from.

(*a*) *Uric Acid.*—Uric acid crystals disappear upon addition of ammonia, and upon evaporation crystals of urate of ammonium appear.

Cystin crystals also dissolve in ammonia, and upon evaporation the crystals reappear.

Cystin crystals are soluble in oxalic or hydrochloric acid, uric acid crystals are not.

(*b*) *Triple Phosphate.*—Triple phosphate crystals are promptly dissolved upon the addition of acetic acid.

Cystin crystals remain unchanged upon addition of this reagent.

MELANIN.

This black pigment occurs pathologically in the urine under certain conditions. Urine containing melanin may be light colored when voided, but upon standing it soon becomes dark. Oxidizing agents, such as sulphuric and hydrochloric acid, turn it intensely black.

Melanin is insoluble in cold alcohol, acetic acid, ether, and dilute mineral acids. It is soluble in boiling acetic acid, boiling strong mineral acids, and in strong solutions of caustic alkalies. It occurs in the urine in the form of small, dark granules resembling particles of carbon.

Detection.—(*a*) The addition of bromine water to urine containing melanin results in the formation of a yellow precipitate, which gradually blackens.

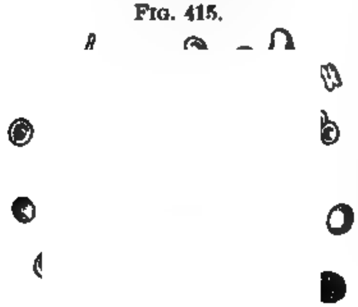
(*b*) The addition of a solution of ferric chloride to melanotic urine yields either a dark-brown cloudiness or a black precipitate, depending upon the concentration of the reagent. Any excess of reagent causes a resolution of the precipitate.

ANATOMICAL SEDIMENTS.

BLOOD-CORPUSCLES.

These bodies are never found in normal urine. When they appear as a deposit in the urine, it is always as the result of some pathological condition. They may be present in large numbers, in which case the urine is distinctly colored by them, or they may require the microscope to aid in their detection. Blood-corpuscles have so characteristic an appearance under the microscope that little difficulty is experienced in distinguishing them from other urinary deposits.

FIG. 415.



Normal Blood Corpuscles. (*After Peyer.*)

These discs are biconcave, and, of a yellowish tint, are smaller than pus-corpuscles, and unlike these contain no nucleus. They retain their characteristic shape in acid urine for a long time, but eventually shrivel somewhat and become more or less stellate in form. In urine of a low specific gravity, the blood-corpuscles swell, become biconvex or even spherical, and lose their optical properties and their coloring matter. In concentrated urine or urine of a high specific gravity, their biconcave character becomes intensified, and they are apt to shrink and become indented at their margins. Acid urine containing a considerable quantity of blood is dark red in color, alkaline urine will appear bright red, the intensity of color, of course, depending upon the quantity of blood present. Blood derived from the kidney is generally evenly

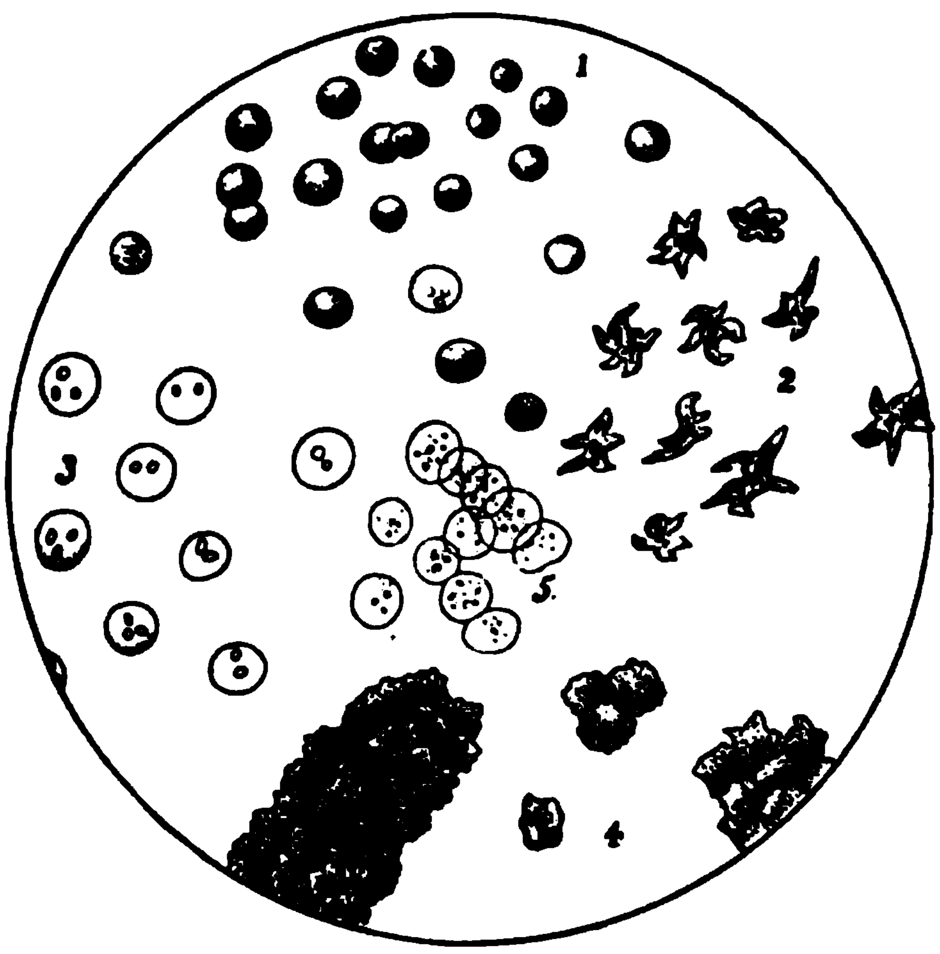
distributed throughout the urine, but that derived from the lower urinary passages at times occurs in clots. Urine containing blood even in minute quantities always responds to the test for albumin.

PUS.

Urine containing pus is always turbid when voided and responds to the tests for albumin. Unaltered pus-corpuscles seen under the microscope present the appearance of circular, finely granular discs, containing distinct nuclei. Their size is nearly double that of a red blood-corpuscle. When treated with acetic acid the nuclei become very distinct, but the granular appearance of the cell-protoplasm disappears.

When examined in the fresh state they exhibit amœboid move-

FIG. 416.



Pus-Corpuscles. (*After Ultzmann.*)

1. Normal corpuscles. 2. Pus-corpuscles with prolongations showing amœboid movements. 3. Pus-corpuscles with nuclei rendered distinct by acetic acid. 4. Pus-corpuscles altered by chronic pyelitis. 5. Pus-corpuscles swollen by ammonium carbonate.

ments, and in this condition are practically identical with mucous corpuscles, or the white corpuscles of the blood and lymph. After death the protoplasmic cell elements become granular, and in this condition we find them in urinary sediments.

Pus may originate from any portion of the urinary tract, and is likely to be mixed with tissue elements from its point of origin. With caustic alkalies, pus-corpuscles swell up and coalesce into a sticky mass, leaving nothing but the nuclei visible under the microscope. This reaction of pus with alkalies forms the basis of Donné's test. At times the deposit of pus-corpuscles resembles that of urates or earthy phosphates; a differentiation, however, is readily made, viz.:—

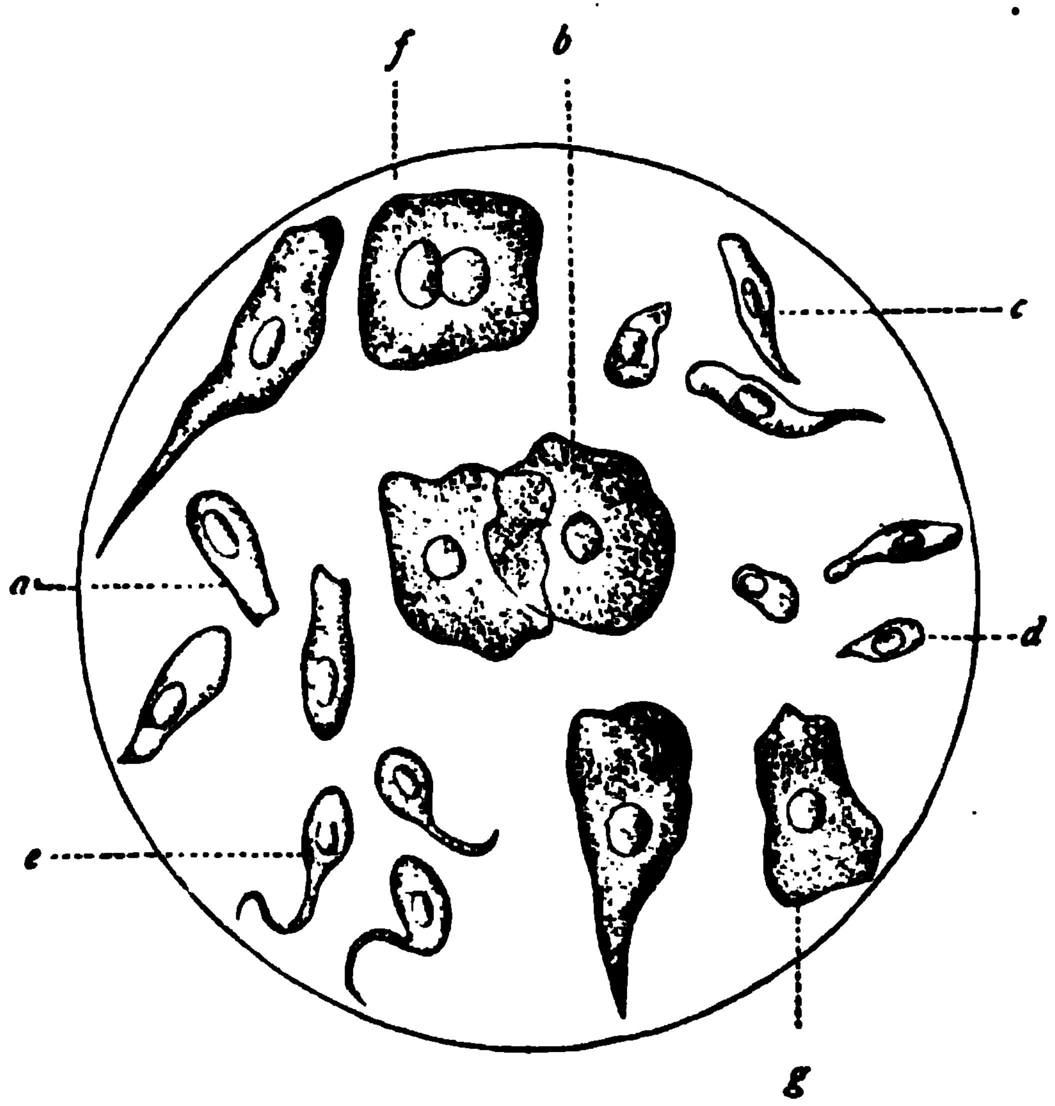
The turbidity or sediment due to urates disappears upon the

application of heat, while that due to pus-corpuscles is apt to be increased by the coagulation of their albuminous elements. The addition of an acid readily dissolves any phosphatic deposit, while in the case of pus the turbidity is made more evident, the acid coagulating the albuminous elements of the pus-cells.

EPITHELIUM.

Every urinary deposit has for one of its component parts some epithelial cells, derived from some part of the urinary tract. These cells are the product of the mucous surfaces over which the urine passes, so that in perfectly normal urine we find representatives of these cells. In pathological conditions, however, these cells

FIG. 417.



Epithelium from Various Parts of the Urinary Tract.

a. Epithelium from the male urethra. b. Vagina. c. Prostate. d. Cowper's Glands. e. Littre's glands. f. Female urethra. g. Bladder.

are often thrown off in such amounts that they constitute a true urinary sediment. The various portions of the urinary tract possess their own special forms of epithelium; it is, however, not often possible to make any valuable deductions regarding the site of a urinary lesion from the character of the epithelium found in the urine, partly because of the comparatively slight differences in the epithelium from different localities, and partly because maceration in the urine destroys to a certain extent its characteristics.

We may, however, distinguish three general varieties of epithelium in urine, viz.:—

(*a*) Round-celled epithelium.
(*b*) Columnar epithelium.
(*c*) Squamous or pavement epithelium.

(*a*) *Round-celled Epithelium.*—These cells in their typical form occur in the convoluted portion of the uriniferous tubules. They are also found in the deep layers of the mucous tract of the renal pelvis, bladder, and male urethra. These cells are small, round, spheroidal, finely granular, and have comparatively large nuclei and nucleoli, and sometimes they contain fatty matter. The cells are larger than pus-cells, containing larger and more distinct nuclei, which are single and require no acetic acid to bring them into view, unlike those of pus-cells. If in a given sediment these cells predominate, and the urine contains albumin, and there are other evidences of renal disease, it may be assumed that the cells in this instance have their origin in the kidney.

(*b*) *Columnar Epithelium.*—This epithelium may be derived from the superficial layer of the mucous membrane of the renal pelvis, or from the deep layers of the bladder, ureters, or urethra. They may, in fact, be said to occur along the entire urinary tract. These cells are irregular in outline, though always elongated, and they are variously described as caudate, spindle-, and cylindrical-shaped. They have a well-marked nucleus visible without the aid of reagents.

(*c*) *Squamous or Pavement Epithelium.*—These cells are chiefly derived from the bladder and vagina, the latter source yielding the larger cell. They are flat, rounded, though irregular in outline. The nucleus is usually central and very distinct.

URINARY CASTS.

The chief views regarding their mode of production and their nature are as follows:—

First. It is supposed that the epithelium of the smaller renal tubules disintegrates, and that the resulting products become packed into moulds by pressure of the urine, until finally they enter the larger straight tubules and are voided with the urine.

Second. That the cast is the result of a secretion of the morbidly irritated epithelium lining the renal tubules.

Third. That they are moulds of the uriniferous tubules, produced by admission into the latter of a coagulable constituent of the blood, which becoming solidified entangles whatever it may have surrounded in the liquid state. It finally slips into the pelvis of the kidney and appears subsequently in the urine.

This latter view is the more generally accepted one.

For purposes of study the following classification may be found useful:—

(*a*) Casts composed of anatomical elements. Under this division are included such casts as are largely composed of red blood cells, leucocytes, epithelial cells, and masses of bacteria.

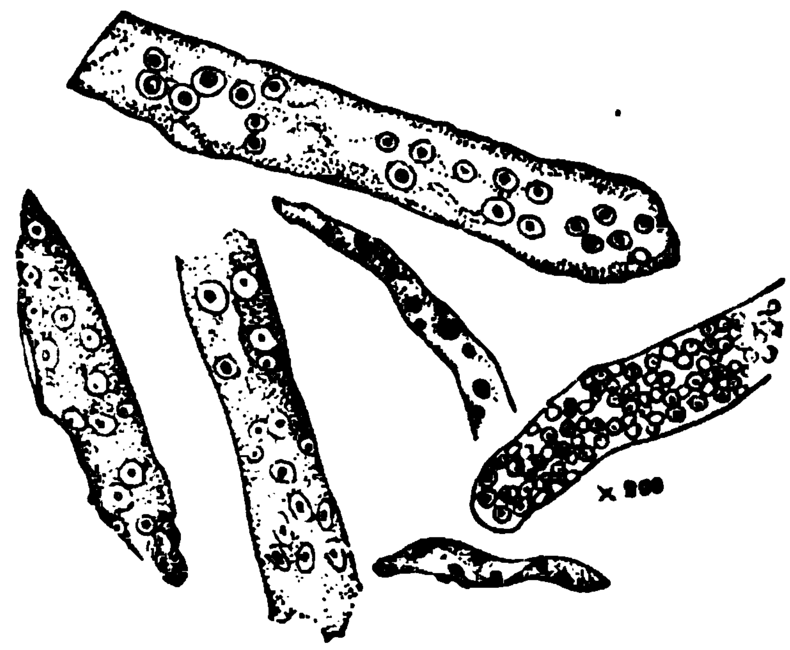
(*b*) Casts consisting of broken-down elements of anatomical structures, such as granular and fatty casts.

(*c*) Casts of whose nature as well as origin little is known. They are called "hyaline" or structureless casts. This division comprises narrow and broad hyaline casts, and composite casts, largely clear, but more or less mixed with elements enumerated in class A and B.

Blood Casts.

They belong to the rarer forms of renal casts, and are usually difficult to find, being obscured by the great number of free red blood-cells that usually accompany them. They are usually short, being often perfect moulds of the tubules; their diameter is nearly uniform throughout, and their ends are often rounded.

FIG. 418.



Blood Casts. (*After Whittaker.*)

Epithelial Casts.

They present themselves in a number of forms. The epithelium of the tubes may be thrown off intact, thus resulting in cylinders of epithelial cells with lumens, or they may occur as solid casts, the body being hyaline and the surface covered either in part or entirely by epithelial cells. At times cells are seen that have undergone granular or fatty degeneration. Rarely do we meet these casts composed entirely of epithelial cells which have become glued together. Epithelial casts are of medium size and length, refract light to a high degree, and can easily be distinguished in the microscopic field.

Pus Casts.

They are usually met with in the form of compound casts, composed of epithelium or granular matter, in which scattering pus cells may be seen. Casts composed entirely of pus-corpuscles are very rare.

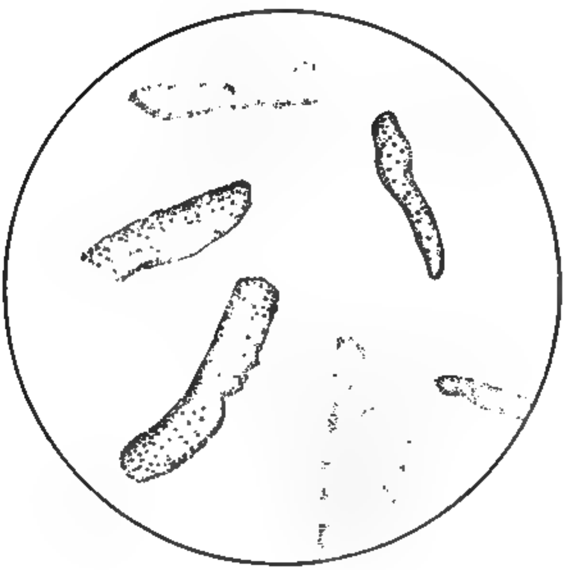
Bacterial Casts.

These casts resemble somewhat the granular casts, but are distinguished from them by their resistance to the action of acids

FIG. 419.

Epithelial Casts. (*After Peyer.*)

FIG. 420.



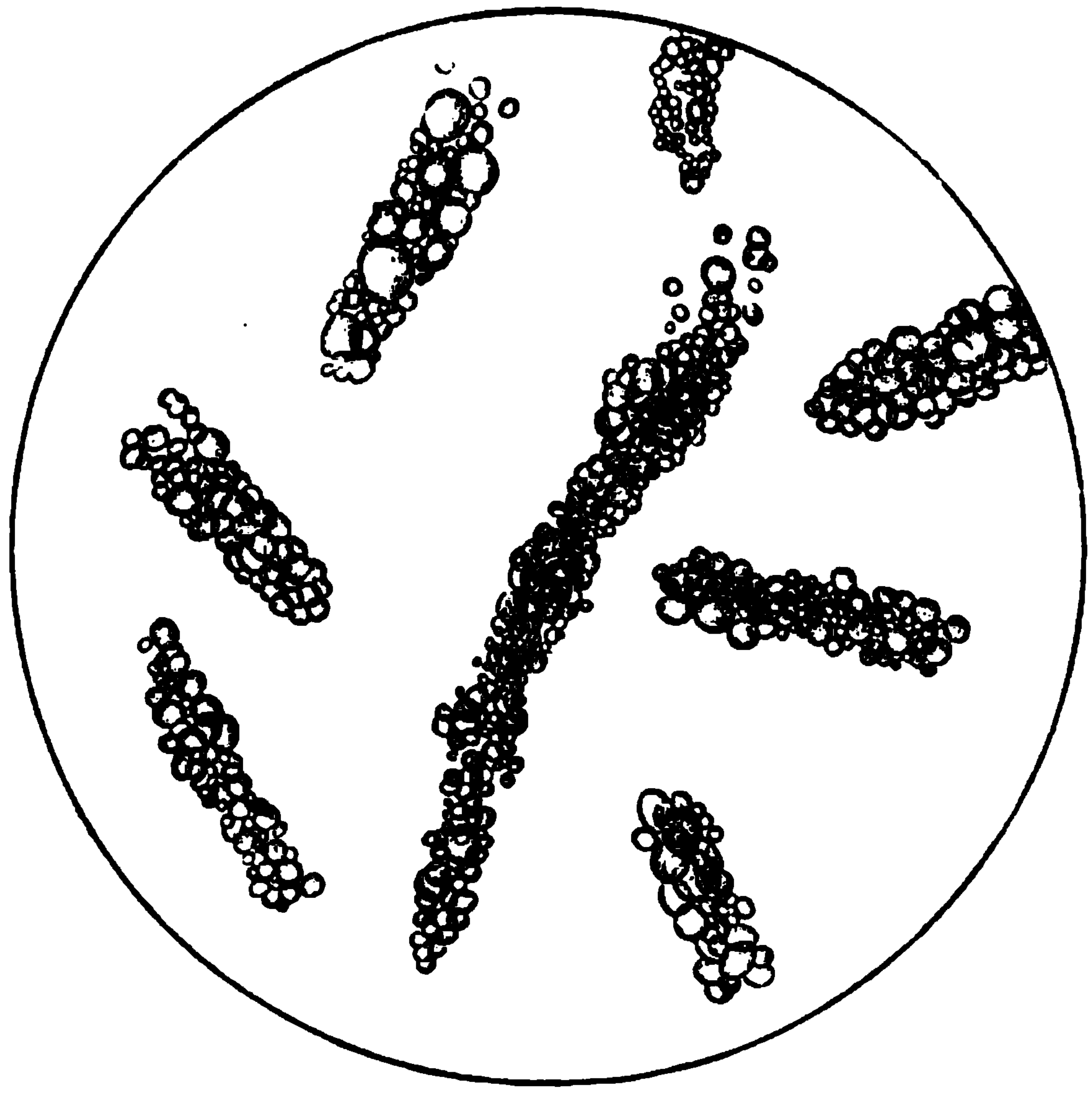
Granular Casts. (*After Peyer.*)

and alkalies. The higher microscopic powers also serve to positively identify the masses of micrococci.

Granular Casts.

Granular casts are the result of a degeneration of anatomical elements, such as blood, pus, or epithelium. They occur in great variety and are designated as finely granular, coarsely granular, granular, highly granular, light granular, and dark granular. They vary considerable in size and shape, rarely preserving their entirety. The granulations may be exceedingly fine or very coarse. They may be white, gray, brown, or yellowish in color, and have scattered over their surface epithelium, white blood-cells, and fat globules.

FIG. 421.



Fatty Casts. (*After Peyer.*)

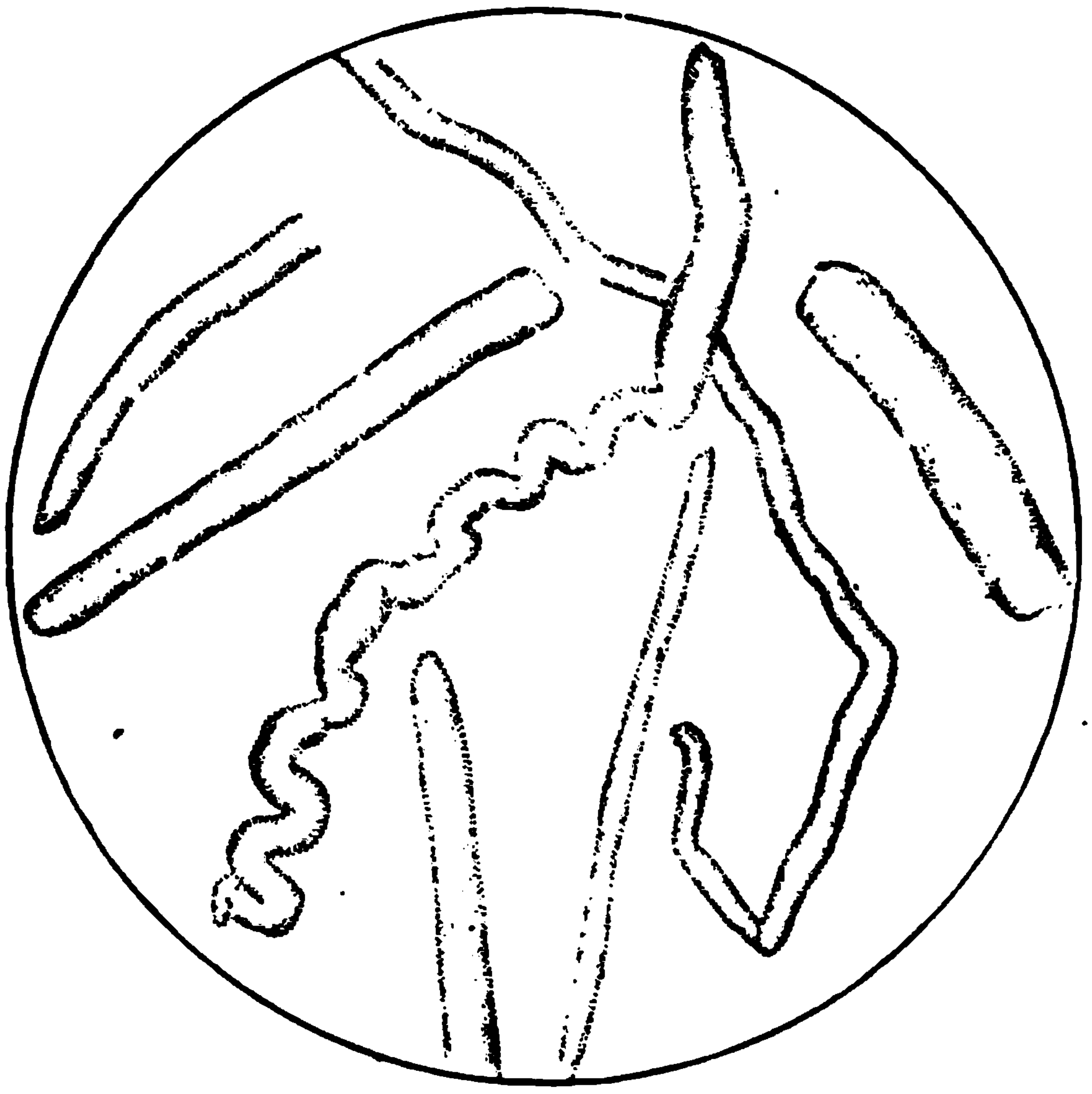
Fatty Casts.

These casts are the result of a fatty degenerative process going on in the kidney. They are generally highly refracting bodies, whose surfaces are studded with fat globules, and at times with fine, needle-like crystals. In addition we often find fatty elements intermingled with the elements of other casts, such as epithelial casts.

Hyaline Casts.

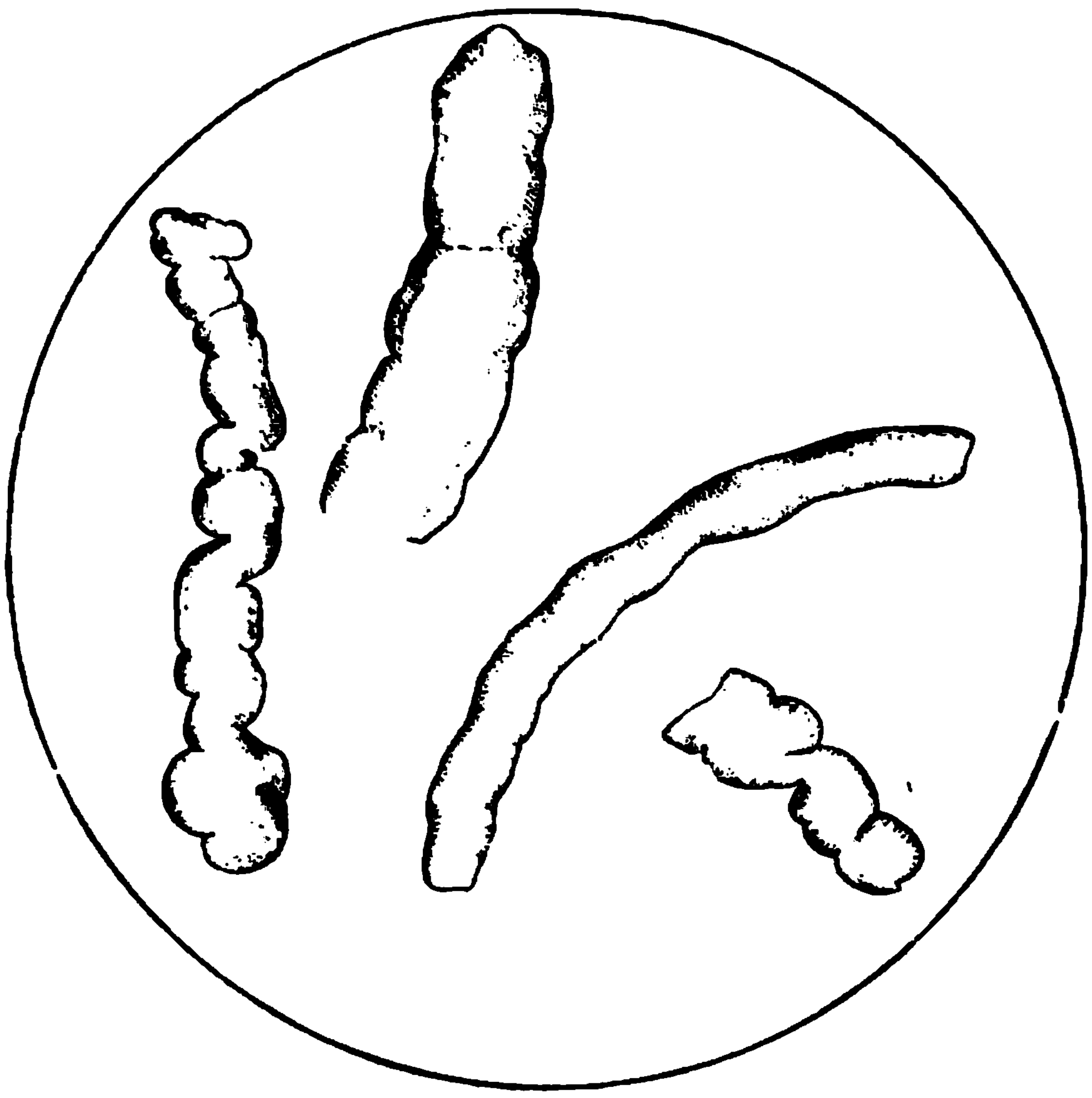
There is a difference of opinion regarding the origin of these casts, one view contending that they are the result of secretion from the epithelial cells lining the renal tubules, while another holds that they are formed by coagulation of the albumin, or possibly its derivatives, excreted with the urine.

FIG. 422.



Narrow Hyaline Casts. (*After Peyer.*)

FIG. 423.



So-called Waxy Casts. (*After Peyer.*)

These structures are pale, of variable length, sometimes exhibiting no granulations whatever upon their surfaces, and in this condition are difficult to detect in a urinary sediment. They more frequently exhibit fine granulations, and at times a fragment of epithelium or a globule of oil may be seen upon their surface. The smaller or narrow hyaline casts originate, without doubt, from the smaller tubules, while the large, broad hyaline casts that are sometimes observed originate evidently from the large, straight tubes of the pyramids.

Another form of hyaline cast, known as the tapeworm form, and at times inappropriately called waxy casts, remains to be described. These casts are large and usually long, and at times

FIG. 424.

False Casts. (*After Peyer.*)

their surfaces are marked by indentations. Some of them exhibit the amyloid reaction, with methyl-violet and iodo-potassic iodine solutions. These casts are of rare occurrence.

Cylindroids.

These structures, known as the cylindroids of Thomas, who first described them, are long, wavy, ribbon-like bodies, which often subdivide at their ends. They are pale and colorless, are longer than any ordinary cast, and rarely have attached to them any cellular elements.

Method of Searching Urine for Casts.—It is necessary to secure a freshly voided specimen of urine, submit it to the action of the centrifugal apparatus two or three minutes, when the sediment

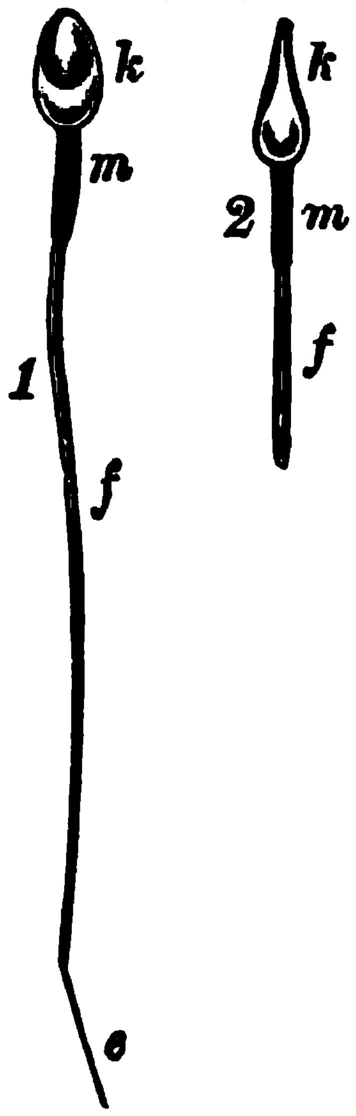
will be obtained in an unaltered form for microscopic examination. The older method of allowing the urine to stand, so that any foreign matter present may subside, besides being tedious, meets with the following objections: (*a*) In a urine of high specific gravity casts settle with difficulty. (*b*) Changes in the urine upon standing often alter the deposit. (*c*) Many times, as the result of such standing, micro-organisms form in such numbers that the microscopic field becomes crowded with them, obscuring other products from vision.

Having obtained the sediment by means of the centrifuge, it is well to examine it in a shallow cell, upon a glass slide, carefully covered with a cover-glass.

SPERMATOZOA.

These bodies are frequently found in the sediment of urine. If they are very abundant they form a flocculent cloud in the urine. They require a power of about 400 diameters to show them well. They are thread-like bodies, having a head and a long, tail-like extremity. The head is oval, flattened, and has a central depression on either side. When freshly ejected they exhibit a vibratile movement, but when seen in urine they are nearly always in the quiescent state.

FIG. 425.



Human Spermatozoa.

1. Human (× 600), the head seen from the side. 2. On edge. *k*. Head. *m*. Middle piece. *f*. Tail. *e*. Terminal filament.

ELEMENTS OF MORBID GROWTHS.

They are seldom seen in the urine. Individual cells may at times be found, and rarer a fragment of a growth may become detached and passed with the urine. If the cells are of large size, multinuclear, and of diverse forms, they may be suspected to be of morbid origin. It is well to remember, however, that many cells may be found in the urine which cannot be considered abnormal.

The fragments of cancerous growths observed are usually of the villous kind, and often show the capillary vessels forming the villus.

BACTERIA.

Normal urine, freshly voided, is free from bacteria, and is therefore an aseptic fluid. Upon standing, however, even at ordinary temperatures, it soon becomes crowded with micro-organisms. Abnormal urine always contains micro-organisms; a great variety of which have been isolated. For an exhaustive study of these micro-organisms the student must be referred to works on bacteriology.

ENTOZOA.

Entozoa are seldom found in the urine in this climate. In a few

instances echinococcus cysts with their hooklets have been seen. In exceptional cases ascarides have been found in the urine, having probably escaped from the lower intestine into the bladder by way of a false opening, or, in the case of women, have reached the bladder through the urethra.

URINARY CONCRETIONS.

The chemical condition of the urine at times gives rise to the separation therefrom of solids, varying in character and density, which may form anywhere along the course of the urinary track, and which may lead to the most serious results. Depending upon their composition and location, they vary in size from a minute particle to the size of a small apple, the smaller ones usually emanating from the kidney or its pelvis, while the larger ones are mainly found in the bladder. According to their size they are spoken of as sand, gravel, stone, and calculi. They may vary in consistence, some being hard while others are soft, and they are generally composed of concentric layers, not necessarily of the same composition. They are classed as *primary*, when the urine from which they are deposited has undergone no decompositional changes; *secondary*, when they are the result of ammoniacal changes in the urine causing a precipitation of its elements, these latter being formed almost exclusively in the lower urinary passages.

A classification, having as its basis the chief constituents of which they are formed, is often made use of. Hence we speak of concretions as follows: Uric acid, urates, calcic oxalate, cystin, xanthin, urostealith, calcic phosphate, calcic carbonate, and calcic phosphate with ammonio-magnesic phosphate. In addition to the ones mentioned, there may occur prostatic calculi and concretions of blood or fibrin. Concretions may consist of one ingredient only, uric acid and calcic oxalate being frequent examples; or they may consist of two or more primary deposits, occurring in distinct alternate layers, giving rise to the term "alternating" calculus. Many of these concretions are built up around a central portion called the nucleus, the rest of the concretion being known as the body, while often in old concretions a crust of phosphatic material has formed. The nucleus may be large or small, and may consist of the same material as the body of the calculus, or, as is most frequently the case, of some organic material, such as a blood-clot, mucus, or epithelium. Rarely foreign bodies introduced into the bladder from without are found acting as nuclei.

URIC ACID CONCRETIONS.

They comprise the majority of stones or calculi met with in the urine of man, ranging from 75 to 90 per cent. They appear in diverse forms and sizes, sometimes as smooth, round bodies, or as

crystalline clusters, or as rough masses, and may occur in particles no larger than a pin-point. They are formed in the kidney or its pelvis, and in their migration through the urinary passage they give rise to pain, often of the most excruciating character, which condition is known as "renal or kidney colic." All these uric acid concretions are characterized by their reddish or yellowish-brown color.

URATE CONCRETIONS.

Urates often occur together with uric acid, and very frequently with calcium oxalate; rarely do they occur alone. Urate concretions do not attain the size of uric acid concretions, nor are they as hard. They are generally of a light gray color, and two or more are united. They are mainly composed of urate of ammonium.

CALCIUM OXALATE CONCRETIONS.

Calculi of pure calcium oxalate are met with, but much more frequently they occur together with uric acid. These concretions are very hard and brittle, and break with an angular fracture. They may occur as large, rough, dark, tuberculated masses, known as the "mulberry calculus," or as small, smooth, rounded, dark-grayish bodies, called "hemp-seed" calculi.

CYSTIN AND XANTHIN CONCRETIONS.

These forms of concretions are rarely met with. Of the latter form there are not a dozen authenticated cases on record. Concretions of cystin are oval in form, of medium size, and break with a crystalline fracture. Upon section they present the appearance of cut bees-wax; exposure to light turns them gray. They are readily soluble in ammonium, from which are deposited upon evaporation their characteristic crystals.

Xanthin concretions are of a whitish, yellowish-brown, or cinnamon-brown color, and vary considerably in size.

CALCIUM PHOSPHATE CONCRETIONS.

This form of calculus is rarely met with in an unmixed state. Earthy phosphates in many urines are deposited freely and persistently, but possess little tendency to concrete, owing to their amorphous condition. In general they present an appearance not unlike that of chalk, and may be dense or loose and spongy in structure, and they break with an amorphous fracture.

CALCIUM CARBONATE CONCRETIONS.

These concretions belong to the rarer forms of calculi. They are usually small in size, with smooth surface, hard in texture, and gray in color. They usually possess a multiple nucleus and break with an angular fracture.

AMMONIO-MAGNESIUM PHOSPHATE CONCRETIONS.

Concretions of marked size, consisting exclusively of triple phosphate, are rare; small concretions are frequent. They are the result always of ammoniacal decomposition.

MIXED PHOSPHATIC CONCRETIONS.

The most common variety is the "fusible calculus," so called because, by aid of the blowpipe, it can be fused into a black, enamel-like mass. It is composed of a mixture of calcium phosphate and triple phosphate. These calculi are often very large, of a grayish-white color, and their surface is often studded with bright, glistening crystals,—triple phosphate. They are friable, exhibiting a concentric arrangement, and are easily separated into thin laminæ. They usually form upon some primary nucleus, such as uric acid or calcium oxalate, or they often occur as incrustations on fungus and other growths in the bladder. The bladder is their chief seat, and they are always the result of ammoniacal urine. This form of calculus is very soluble in mineral acids.

RARE FORMS OF CONCRETIONS.

Other concretions of rare occurrence may be mentioned, such as fatty concretions, to which the name of urostealith is applied, indigo concretions, fibrine and blood concretions, and prostatic concretions, the latter not of urinary origin, but sometimes found in the urine.

ANALYSIS OF CALCULI.

The larger calculi, as we have learned, in nearly all instances are composed of various layers of chemically different bodies. Their probable composition, and the direction in which the chemical analysis should be pursued, is often indicated by a close study of their form, color, size, and density. To ascertain the several component parts it is necessary to divide the concretion into parts. If it be brittle, breaking it into pieces often answers the purpose; if hard, it may be divided into sections by means of a fine saw, or it may be ground down to one-half on a stone. The different layers will now be plainly visible, and portions of each layer may be separated for individual examination. Portions of the concretion are now reduced to a fine powder, and tested by heating on platinum foil, either by means of an alcohol lamp or a blowpipe.

According to the results obtained by this procedure, concretions are divided into three classes, viz.:—

(*a*) Such as leave very little or no residue.

(*b*) Such as leave a moderate residue.

(*c*) Such as are not affected by heat, or only to a very moderate extent.

The first class comprises such organic deposits as uric acid, ammonium urate, xanthin, cystin, proteid substances, fatty bodies, and indigo. To determine which of these organic deposits are present, we proceed as follows:—

Uric Acid.—Treat a small quantity of the finely powdered concretion with nitric acid, evaporate to dryness, and cool; now add a drop of ammonia water, and observe a purple color (murexid test).

Ammonium Urate.—Treat the powdered concrete with hot water, thus dissolving the ammonium urate, decant the watery solution, and allow it to cool, and to the deposit formed upon cooling add potassium hydrate and boil; if ammonium be present, it will be recognized by its odor or by its action on moist red litmus-paper.

Xanthin exhibits no reaction with the murexid test, but its nitric acid solution upon evaporation leaves a bright-yellow residue, soluble in potassium hydrate, with resulting yellowish-red color.

Cystin may be presumed to be present if during combustion sulphurous vapors arise. Or if it be dissolved in potassium hydrate, and boiled with lead acetate, a black precipitate composed of lead sulphide forms. If a specimen of the powder containing cystin be treated with ammonic hydrate, filtered and evaporated, hexagonal tables thereof will be detected under the microscope. Cystin does not give the murexid reaction.

Protein concretions upon heating evolve the odor of burnt horn or feathers. They are soluble in potassic hydrate.

Urostealith melts on heating, giving off an aromatic odor. It is soluble in ether, and in warm solutions of potassic hydrate.

Indigo yields purple vapors on combustion, resulting in a dark blue crystalline sublimate. It dissolves in sulphuric acid with blue color.

The second class comprises such deposits as the urates of the fixed alkalies, viz., sodium and potassium urates, urate of calcium, urate of magnesium, and calcium oxalate.

Potassic Urate gives the murexid reaction. The residue after combustion is treated with water, to which it imparts an alkaline reaction, and upon neutralization it yields with platinic chloride a yellow precipitate.

Sodium Urate also gives the murexid reaction, and imparts its characteristic yellow color to the flame.

Calcium Urate. The residue after combustion is almost insoluble in water and feebly alkaline. Acetic acid dissolves it readily, and upon the addition of ammonic oxalate a white precipitate forms. It gives the murexid reaction.

Magnesium Urate. After combustion the residue is found to be almost insoluble in water, but soluble in acetic acid. With disodic phosphate and ammonia a crystalline precipitate of triple phosphate is formed; no precipitate with calcium oxalate. It gives the murexid reaction.

Calcium Oxalate does not give the murexid reaction. Treat the powdered concretion with acetic acid and notice the failure to dissolve. Now dissolve in a mineral acid; no effervescence is observed. The residue after moderate combustion is soluble in acids with effervescence.

The third class comprises calcium carbonate, magnesium carbonate, triple phosphate, and neutral calcium phosphate. No member of this group responds to the murexid test.

Calcium Carbonate. Treat powder with acetic acid, and note the ready solution with effervescence; now add ammonium oxalate and a crystalline precipitate is formed.

Magnesium Carbonate. Treat the powdered concrete with acetic acid, in which it dissolves with effervescence. With disodic phosphate and ammonia the solution gives a crystalline precipitate of triple phosphate.

Ammonio-Magnesium Phosphate usually occurs together with more or less neutral calcium phosphate, forming the so-called mixed phosphatic or fusible calculus. Upon ignition it melts into an enamel-like mass. Upon prolonged ignition they do exhibit the alkaline reaction of calcium carbonate and oxalate. The fused mass dissolves in hydrochloric acid without effervescence.

The annexed table, from Heller, will be found valuable by the student, greatly facilitating the analysis of calculi :—

Does not burn.	*The powder when treated with HCl.*	Effervesces.		*Calcium Carbonate.*
Does not burn.	*The powder when treated with HCl.* — *Does not effervesce.*	*The gently heated powder with HCl.*	Effervesces.	*Calcium Oxalate.*
Does not burn.	*The powder when treated with HCl.* — *Does not effervesce.*	*The gently heated powder with HCl.* — *The powder when moistened with a little KHO.*	No NH_3 or, at least, only traces of NH_3. Powder dissolves in acetic acid or HCl. This solution is precipitated by ammonia (amorphous).	*Bone Earth (Magnesium and Calcium Phosphate).*
Does not burn.	*The powder when treated with HCl.* — *Does not effervesce.*	*The gently heated powder with HCl.* — *The powder when moistened with a little KHO.*	Abundant ammonia. The powder dissolves in acetic acid or HCl. This solution gives a crystalline precipitate with ammonia.	*Triple Phosphate (mixed with unknown amounts of Earthy Phosphate).*
Does burn.	*With flame.*		Flame yellow, continuous. Odor of burnt feathers. Insoluble in alcohol and ether. Soluble in KHO with heat. Precipitated herefrom by acetic acid and generation of H_2S.	*Fibrin.*
Does burn.	*With flame.*		Flame yellow, pale, continuous. Odor of resin or shellac on burning. Powder soluble in alcohol and ether.	*Urostealith.*
Does burn.	*With flame.*		Flame pale blue, burns a short time. Peculiar sharp odor. The powder dissolves in ammonia, and six-sided plates separate on the spontaneous evaporation of the ammonia.	*Cystin.*
Does burn.	*Without flame.*		Does not give murexid test. The powder dissolves in HNO_3 without effervescence. The dried yellow residue becomes orange with alkali, beautiful red on warming.	*Xanthin.*
Does burn.	*Without flame.* — *The powder gives the murexid test.*	*The powder when treated with KOH gives*	Strong ammonium reaction.	*Ammonium Urate.*
Does burn.	*Without flame.* — *The powder gives the murexid test.*	*The powder when treated with KOH gives*	No noticeable ammonium reaction.	*Uric Acid.*

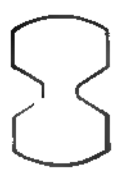
CHAPTER XXXIX.

THE MICROSCOPE IN PHARMACY.

While it is undoubtedly true that one must look to the pharmaceutical chemist for both the quantitative and qualitative determination of plant constituents, yet the skillful microscopist can often shorten the path in analysis and keep a check upon the chemical results. Many plant constituents are directly recognizable by means of the compound microscope, and when microchemical tests are employed in addition, there are few plant pro-

FIG. 426. FIG. 427.

FIG. 428.



Types of Simple Microscopes, or Magnifying Glasses.

ducts that cannot be detected. The details of such tests form the matter of many standard works of reference, which cannot be consulted without a working knowledge of the microscope. The object of the present chapter, therefore, is to describe the microscope, its parts, both mechanical and optical, and its principles, with such additions of a technical nature that would enable the student to apply the instrument in practical pharmacy.

Microscopes are divided into two kinds, the *simple* and the *compound*.

The SIMPLE MICROSCOPE, or magnifying glass, consists of one

or several double convex lenses, and gives a direct image of the object. This image is erect; the field of view is generally extensive, and the magnification is limited, varying from one to twenty times the size of the object.

The use of the simple microscope in pharmacy is limited, for beyond the determination of the general character of crystals and the general aspect of precipitates it is of little value.

Special forms of magnifying glasses, such as the dissecting microscopes, have little use save for pharmacognostical or botanical purposes.

The COMPOUND MICROSCOPE is an optical instrument constructed for the purpose of magnifying small objects, and differs from the simple microscope in that it magnifies the magnification of the object. Compound microscopes may be very simple in construction, consisting of but few lenses, but the principles involved are always the same.

In the compound microscope the image is inverted, the field of view is small, the illumination or light coming from the object is diminished, and the magnification is much increased.

The parts of a compound microscope may be conveniently divided into two groups: the mechanical and the optical. A reference to the accompanying illustration will serve to locate the parts named and described.

The mechanical parts are the base, or foot; the pillar, below stage and above stage, with a hinge joint between; tube, or body; draw tube; rack and pinion, or coarse adjustment; micrometer screw, or fine adjustment; stage; nose-piece; stage clips; diaphragm; mirror bar; sub-stage, if present.

The optical parts are oculars, or eye-pieces; objectives; mirror; condenser.

DESCRIPTION OF PARTS.

The MECHANICAL parts or parts of the STAND proper.

The *base* or *foot* is that part which supports the microscope. It is made in various shapes: triangular, circular, or horse-shoe. It should be firm, and heavy enough to allow the microscope to be tilted upon its axis and still stand steady.

It bears the *pillar*, which has a portion below and above the stage, which is broken by a hinge joint (not always present), which allows the microscope to be inclined at any angle.

To the pillar is attached the *stage* and the *arm*. The *stage* is generally round or square, and should be firm, flat, and large, at least four inches across. It is perforated at the centre by an *aperture*, which allows the light to pass through it to illuminate the object. It also has a pair of *clips* to hold the glass slide in place.

The *arm* bears the *body* or *tube*. A firm arm is an essential to a good microscope.

The *body* or *tube* is attached to the arm by means of a *rack and pinion* piece. This is called the *coarse adjustment*, and permits the

tube to be lowered or raised. The *fine adjustment* consists of a micrometer screw situated at the top of the pillar.

FIG. 429.

Eye-Piece or Ocular.

Fine

Compound Microscope.

The *tube* frequently has a draw tube, into the upper end of which the *ocular* or *eye-piece* is set. To the lower end of the tube

the *objectives* are attached. In most modern instruments there is added an especial apparatus called the *nose-piece*, to which two

FIG. 430.

Iris Diaphragm.

or more objectives may be attached, any one of which may thus be brought into position.

FIG. 431.

Abbé
Condens

Sub-Stage Apparatus.

Below the stage there may be a *sub-stage*, which may be provided with a *condenser*, the Abbé being the best. From the lower portion of the stage near the pillar the *mirror bar* descends, carry-

ing the *mirror*, and in some instances a *diaphragm*. In some instruments the diaphragm is situated just below the aperture, and may be of several types; the most useful one is the *iris diaphragm*, as displayed in the cut. (Fig. 430.)

In the best of modern instruments the whole sub-stage arrangements are bound together in one mechanism, as in the following illustration. (Fig. 431.)

THE OPTICAL PARTS.

The *ocular* or *eye-piece* is set into the upper portion of the tube. There are two types of eye-pieces, the negative, or Huyghenian, which is the more commonly used, and the positive, or Ramsden, now rarely seen in microscopic use. In the more advanced types of instruments there is the so-called compensating ocular, which is, however, only used with the newer apochromatic objectives.

FIG. 432. FIG. 433.

Eye-Pieces.

The action of the eye-piece is that of a simple magnifier, but it magnifies the real image which the objective produces, as if that image were the original object.

Oculars are designated as high and low, and are measured in inches or millimeters; the longer the ocular, the lower or weaker it is in magnifying power, and *vice-versâ*. (Figs. 432, 433.)

The *objective* is often called the most important part of the instrument, which is, in many senses, true, for the great advances that have come about in the biological sciences have been mainly due to the advances that have been made in the construction of the objectives.

The objective is placed at the lower end of the tube, either fitting directly into the tube, or into the nose-piece by means of what is known as the Society Screw, which is an internationally adopted size, so that any objective can be used in any stand.

The objective is made up of a series of lenses varying from two to four, and works in a combination as a simple magnifier; it forms a real inverted image in the tube, which is further magnified by the ocular.

Objectives are designated either arbitrarily, as a, b, c, d, e, etc., or according to a system of measurements expressed in fractions in the English or in the metric system. These measurements signify that the magnifying power of any lens, say a $\frac{1}{2}$ inch objective, is equal to the magnifying power of a simple lens whose focal distance equals $\frac{1}{2}$ inch. In general, therefore, the lower the fraction which designates the lens, the higher is the power of magnification. For general purposes, "the smaller the front lens, the higher the power," is a good guide for the student to enable him to know which is the high power and which the low. It should also be remembered that, as a rule, the higher the magnification, the less working distance, the less field, and the less illumination. (Fig. 434.)

FIG. 434.

Construction of Objective.

The *mirror* is attached to the mirror bar beneath the stage, and is freely movable. It consists generally of two surfaces, a plane and a concave, the latter of which is generally used; it should be of ample width, at least two inches.

The *condenser*, when present, is situated just below the stage, and if of the Abbé type, is well represented in the illustration; it is used to give a greater supply of light to the objective, and is invaluable in working with stained specimens, which are to be differentiated by means of color rather than by outline. For the best work it is an essential adjunct to the microscope. (Fig. 431.)

CHOICE OF A MICROSCOPE.

In choosing a microscope for use in the pharmaceutical laboratory, a few cardinal principles may be borne in mind. As many differences of opinion will be found among working microscopists, the question must be left to optical principles; for any microscopist, after working many years with a particular type of instrument, may become so proficient in its use, that, notwithstanding radical errors in its construction, good work can be done. Individual bias should not, therefore, govern the purchaser.

Firmness and solidity are virtues in a microscope, and as these qualities are given by the base, the pillar, and the arm, these parts should be strong and solid, not necessarily massive. We

prefer the so-called Continental type, as giving compactness, firmness, and solidity.

The stage should be ample; a square is perhaps preferable, and it should be thick and firm. The pharmacist will often use corrosive substances in his investigations, and the stage would better be of metal, not of gutta-percha.

A coarse adjustment, preferably a rack and pinion, that will not wobble, and that will not allow the tube to descend of its own weight, is a requisite. A fine adjustment is an essential; it should work evenly and smoothly, and is preferably placed at the top of the pillar.

A nose piece, double or triple, is now considered a necessity. Care should be taken that it centres the objectives, and that its joints do not leak.

As the objective is the most important part, a few words regarding its choice may be of benefit. Two errors of construction should be borne in mind; these are chromatic and spherical aberration.

Chromatic aberration is a defect due to the double action of a lens, by which it acts as a magnifier and as a prism. Acting as a prism, it decomposes the light into its elements, and if a lens shows bands of color around the edges of the object looked at, it has not been totally " corrected " for chromatic aberration.

Spherical aberration is a second defect whereby all points of an image are not brought together, so that in looking at a piece of fine wire netting, for instance, the fibres in the centre are straight and distinct, while those on the outside are found to be curved and blurred.

A certain amount of spherical aberration is necessary in high power objectives, but by means of the diaphragm the outer portions can be cut out of view.

Most modern objectives are carefully corrected for both these errors, but they should be remembered by the purchaser.

Good lenses should also possess good defining power, that is, the image should be distinct, especially at its outer borders; the diaphragm has much to do with the distinctness of the image, and care should be taken to limit the amount of light when one is testing a lens for its defining power. Penetrating power renders a lens capable of seeing clearly into an object.

Flatness of field must vary with the magnifying power and angle of aperture of the lens. A flat field is one in which all the parts of the field are in focus at the same time. Regarding the angle of aperture little need here be said, save that it represents the pencil of light that the lens is able to take in and use in forming an image; and that the angle of aperture of a lens more clearly tells its powers than the tables of magnification. Wide-angled lenses that are properly corrected are to be preferred.

Good working distance is of great importance to the micros-

copist in the pharmaceutical laboratory, and such objectives should be chosen that have this quality, even if a certain amount of magnification should be sacrificed. It means that there should be an appreciable distance between the front lens and the object. In low-power objectives it is of little concern; but in the higher powers it becomes important, especially to the pharmacist who may desire to look at some crystals in a fluid in a watch crystal; if he has a lens with a short working distance, it may be impossible, because the objective will not focus unless stuck into the liquid, and this destroys the image, whereas a long working distance lens would give the requisite ability to manipulate the object.

It is to be taken for granted that the pharmacist knows how to use the microscope, but the following brief directions may be of service to the beginner.

The working table should be firm and is best about 28 or 30 inches in height. The light from an illumined cloud is the best light to be used and most microscopists prefer the north light. Any light can be used, but not too much. When using a lamp the light from the ground glass globe is preferable to that from the wick.

The microscope should be placed directly in front of the observer, with the pillar facing backward. To get the light, the mirror, preferably the concave side, should be so turned as to throw the beam directly up through the aperture. All work should be begun with the low-power objective. Having obtained the illumination of the object, which may be mounted on a slide or held in a glass evaporating dish, this object is placed as near the centre of the stage as the eye can approximate, when by means of the coarse adjustment the low power is lowered as near the object as possible, without touching it; then with the eye over the ocular, the tube should be gradually raised by means of the coarse adjustment, until the object is in an approximate focus; the exact focus can then be obtained by means of the fine adjustment. In general it is not necessary to turn the fine adjustment more than one revolution.

Having observed what was necessary with the low power, the portion of the object further to be investigated should be moved so as to come in the centre of the field, the observer still looking into the microscope.

The tube is then raised and the high power substituted, and the process of focusing as already outlined repeated. It is essential in using the high powers to exercise great care. The objective approaches the object as near as it can be placed, and then with the eye over the ocular the tube is raised very slowly by means of the coarse adjustment until the focus is reached; then the focus is completed as before by means of the fine adjustment.

To illustrate the value of the diaphragm the following experiment may be tried. A thin transparent object should be selected

and brought into focus with the low power; then the diaphragm should be opened as wide as possible and later gradually closed; it will now be seen that as the diaphragm is closed the outlines of the object become more distinct, until a point is reached when the light is so much diminished that the object is no more visible. It is a lesson of experience to make the exact compromise between the amount of definition and the amount of illumination.

ACCESSORIES.

Stage micrometer.
Ocular micrometer.
Camera lucida.

In the pharmaceutical laboratory quantitative estimations are desirable, and to ascertain the size, as well as the shapes of objects studied, is a necessity. To this end the microscopist makes use

Fig. 436.

Fig. 435.

Eye-Piece Micrometer.

Ocular for Eye-Piece Micrometer, showing Shelf in centre upon which the Micrometer rests.

of instruments for measuring. The most useful is the *eye-piece micrometer*.

This generally consists of a circle of glass, accurately ruled, which slips into the eye-piece and rests upon a diaphragm. The accompanying figures illustrate this accessory.

The eye-piece micrometer must be standardized before using, by means of a *stage micrometer*, which generally is made upon a glass slide. In the centre of the glass slide there is a finely ruled scale, usually of one millimeter divided into 100 parts.

This serves as a standard, and the eye-piece micrometer is measured in the following way: With a given eye-piece, say 2 inches, and a given objective, $\frac{1}{8}$, and a standard tube length, 160 millimeters, the stage micrometer is brought into focus. The eye-piece micrometer is then introduced and its divisions are compared with the divisions of the stage micrometer. It is best to

take the entire 50 divisions of the eye-piece micrometer and compare their length with the divisions of the stage micrometer.

If these 50 divisions are found to measure 7 divisions on the stage micrometer, then 50 lines on the eye-piece micrometer equals 7 on the stage micrometer. Each division of the stage micrometer equals $\frac{1}{100}$ of a millimeter, hence the 50 lines of the stage micrometer equal $\frac{7}{100}$ of a millimeter, and each division of the eye-piece micrometer equals $\frac{1}{50}$ of $\frac{7}{100}$, or $\frac{7}{5000}$, or $\frac{14}{10000} = .0014$ mm. $= 1\frac{4}{10}\ \mu$, or mikrons, or micro-millimeters.

Having standardized the eye-piece micrometer for both eye-pieces and both objectives, and entered a note of the values on a card for reference, it can then be used to measure any object, as, for instance, starch grains, or oil globules, or resin masses.

If the pharmacist is to do any research work, accurate delineations of the object seen are requisite; for this purpose some drawing apparatus will be found of service. The well-known Abbé camera lucida is the best instrument in the market at the present time for this purpose, though other excellent instruments are to be had for a much smaller price.

The accompanying illustration represents one of the simpler

FIG. 437.

One of the Simpler Forms of Abbé Cameras.

forms of the Abbé cameras. The latest and most perfected instruments are to be recommended.

In drawing, the microscope must be erect and the drawing table horizontal, and the axis of the drawing should correspond to the axis of microscope, else distortion of the image will result. Special drawing tables are in the market, but are not necessities for the present purposes.

A polariscope attachment is of great service in the hands of the pharmaceutical microscopist, as it can abridge many of his investigations. It is not, however, indispensable.

It has been considered expedient that a list of common plant constituents be here included and some of their more important micro-chemical tests be indicated. For a more extended consid-

eration of the subject the student is referred to the bibliography at the end of the chapter.

Plant constituents practically mean cell contents, and the microscopist finds the various substances he is called upon to test resident in the cavities of cells, either living or dead; either as functionally active parts of the plant body, or as reserve products or the products of destructive metabolism. A classification of the more important cell contents is here appended:—

1. The unformed nitrogenous contents.
2. The formed nitrogenous contents.
3. The non-nitrogenous contents.
4. The cell sap, containing organic and inorganic substances in solution.

(1) The unformed nitrogenous substance forms the so-called cytoplasm of the cell bodies, and is found most abundantly in the more rapidly growing parts of the plant, and hence is to be looked for in young and delicate tissues. It is rarely found in the laboratory in the living condition; but when dried it forms the major part of the so-called albumin that is to be found in the reports of analyses. Micro-chemically, it is to be detected by means of its color reactions; with iodine yielding a brown to yellowish stain; by Millon's reagent giving a rosy red, and by the xanthoproteic reaction (HNO_3 + KOH), a yellowish to brownish color.

(2) Of the formed nitrogenous contents, the most important are the aleurone grains and the chromatophores. While these are of interest from the standpoint of inner morphology, the pharmaceutical chemist can regard them only as nitrogenous compounds, and cannot attempt, by chemical means, to separate them from the first class. It is in such cases that the microscope can be of service in determining the morphological elements, and thus widen the conception of the chemist's analysis.

(3) Of the non-nitrogenous cell contents there are to be considered, with a greater or less degree of minuteness, oils, fats, starch, amylodextrin, sulphur, and plant crystals.

The *fats* and *oils* can generally be detected as small globules of a yellowish or brownish color, circular or slightly oval and of a high refractive index. They are generally found lying free in the cell cavities. In powdered drugs they are disassociated and sometimes run together in masses. Micro-chemically, osmic acid, 10 per cent., stains them black; they are saponified by the alkalies, a weak solution of KOH being sufficient; tincture of alcanna stains fat and oil globules bright red. Absolute alcohol distinguishes the fixed oils and fats from the essential oils; the former are insoluble, the latter soluble. A characteristic reaction is seen when a section of a plant to be investigated is placed upon the slide in glycerine and slightly warmed. The fats and fatty acids melt, at first in drops, and then by slow cooling crystallize in long needle-shaped crystals collected in bundles.

Starch is distinguished both morphologically and micro-chemically with great readiness. It makes a characteristic reaction with iodine solution, varying with the strength of the solution and the length of application from blue to violet to black; alkalies destroy the coloration and acids restore it.

The *crystals* of the calcium salts, oxalate, phosphate, and sulphate, are of interest from the botanical standpoint rather than the chemical.

(4) The constituents of the cell sap are the most numerous of the cell contents, and much research is necessary to differentiate all the substances thus far described; hence they can be hardly more than touched upon in this chapter. These materials in solution include, hesperidin, inulin, asparagin, tyrosin, aloin, sugar, mucilage, tannins, alkaloids, glucosides, bitter stuffs, ethereal oils, gums, resins, rubbers, milky juices, balsams, plant acids, and various crystals. A number of these are of little importance save in the most detailed investigations, while others are constantly determined by chemical means, and their presence can frequently be made evident by means of the microscope. The more important constituents from our present standpoint are tannin, resins, sugar, wax, the alkaloids, and the glucosides.

Sugar.—Although Trommer's and Fehling's tests are most often given for the detection of sugar, it is not an easy matter to determine its presence in small quantities; Phenylhydrazine acetate has given satisfactory results in our experience when the amount of sugar has been very small. *Tannin* is found extensively in plants, generally dissolved in the cell sap, especially of the bark; it is often found in granular form also. As a general micro-chemical reagent for tannin, ferric chloride is used, either in aqueous or alcoholic solutions. Ferric sulphate and acetate give less intense reactions. If a substance is impregnated with any of these mixtures, the masses of tannin or the cellulose membranes impregnated with tannin give a bluish or greenish reaction, strong solutions giving a blue-black or greenish-black reaction. The tannin in galls, oak for instance, give the bluish reactions, whereas rhatany, coffee, and male fern give the greenish reaction. Potassium bichromate is also of value, giving after some time a reddish coloration. A dilute solution of zinc chloride gives a reddish violet coloration with tannin.

Resins are found either fluid or in more or less solid granules, sometimes lying in the cell wall, sometimes in special secretory reservoirs, or partly saturating the cell walls. The resins are generally brownish in color, and if in grains, irregular in shape. Tincture of alcanna, 50 per cent., stains resin a cinnamon red. A solution of equal parts methyl-violet, fuchsin, and alcohol (Hanstein) produces a blue, or clear green, or dirty green color.

The *alkaloids* and *glucosides*, microscopically, are more of a hope than a reality in practical work, for in their natural condition they are difficult if not impossible to recognize. Micro-chem-

ically, however, much can be done in their determination, but the work is for the advanced student rather than the tyro, and to undertake it one should consult the works here noted.

WORKS OF REFERENCE.

The student is referred to the following works: On microscopy proper—Gage, "The Microscope and Microscopical Methods;" and for micro-chemical tests of plant constituents, Zimmermann, "Microtechnique," translated by J. E. Humphreys, H. Holt, N.Y. Behrens, "Guide to the Microscope in Botany," S. E. Cassino, Boston.

These two works are well provided with bibliographical references, to which the student is referred.

APPENDIX.

TABLE OF ATOMIC WEIGHTS.

According to L. Meyer and K. Seubert.

Name.	Symbol.	Atomic Weight.	Name.	Symbol.	Atomic Weight.
Aluminum, ...	Al	27.04	Molybdenum, . .	Mo	95.9
Antimony, ...	Sb	119.6	Nickel, ...	Ni	58.6
Arsenic, ...	As	74.9	Nitrogen, ...	N	14.01
Barium, ...	Ba	136.9	Osmium, ...	Os	190.3
Beryllium,*	Be	9.03	Oxygen, ...	O	15.96
Bismuth, ...	Bi	208.9	Palladium, ...	Pd	106.35
Boron, ...	B	10.9	Phosphorus, . . .	P	30.96
Bromine, ...	Br	79.76	Platinum, ...	Pt	194.3
Cadmium, ...	Cd	111.5	Potassium, ...	K	39.03
Cæsium, ...	Cs	132.7	Rhodium, ...	Rh	102.9
Calcium, ...	Ca	39.91	Rubidium, ...	Rb	85.2
Carbon, ...	C	11.97	Ruthenium, ...	Ru	101.4
Cerium, ...	Ce	139.9	Samarium, ...	Sm	149.62
Chlorine, ...	Cl	35.37	Scandium, ...	Sc	43.97
Chromium, ...	Cr	52.0	Selenium, ...	Se	78.87
Cobalt, ...	Co	58.6	Silicon, ...	Si	28.3
Columbium,† . . .	Cb	93.7	Silver, ...	Ag	107.66
Copper, ...	Cu	63.18	Sodium, ...	Na	23.0
Didymium,‡ . . .	Di	142.0	Strontium, ...	Sr	87.3
Erbium, ...	Er	166.0	Sulphur, ...	S	31.98
Fluorine, ...	F	19.0	Tantalum, ...	Ta	182.0
Gallium, ...	Ga	69.9	Tellurium, ...	Te	125.0
Germanium, . . .	Ge	72.3	Terbium, ...	Tb	159.1
Gold, ...	Au	196.7	Thallium, ...	Tl	203.7
Hydrogen, ...	H	1.0	Thorium, ...	Th	231.9
Indium, ...	In	113.6	Tin, ...	Sn	118.8
Iodine, ...	I	126.53	Titanium, ...	Ti	48.0
Iridium, ...	Ir	192.5	Tungsten, ...	W	183.6
Iron, ...	Fe	55.88	Uranium, ...	U	238.8
Lanthanum, . . .	La	138.2	Vanadium, ...	V	51.1
Lead, ...	Pb	206.4	Ytterbium, ...	Yb	172.6
Lithium, ...	Li	7.01	Yttrium, ...	Yt	88.9
Magnesium, ...	Mg	24.3	Zinc, ...	Zn	65.1
Manganese, ...	Mn	54.8	Zirconium, ...	Zr	90.4
Mercury, ...	Hg	199.8			

* Also called Glucinum, Gl = 9.03.

† Also called Niobium, Nb = 93.7.

‡ Composed of Neo- and Praseo-Didymium.

TABLE OF SOLUBILITIES.*

IN WATER, ALCOHOL, ETHER, CHLOROFORM AND GLYCERIN, OF MEDICINAL SUBSTANCES OFFICIAL IN THE U. S. PHARMACOPŒIA, INCLUDING MANY OTHERS OF COMMON OR FREQUENT USE.

ABBREVIATIONS—*s.*, soluble; *v. s.*, very soluble; *sp.*, sparingly; *a.*, all proportions; *sl.*, slightly; *ins.*, insoluble; *n. ins.*, nearly insoluble; *dec.*, decomposed.

MEDICINAL SUBSTANCES. One part is soluble in [at 59° F (15° C.) U. S. P. Standard Temperature.]	PARTS OF Water.	Alcohol.	Ether.	Chloroform.	Glycerin.
Acacia,	2	ins.	...	...	...
Acetanilid,	194	5	18	v. s.	...
Acid, Arsenic,	2	...	...	...	5
Arsenous,	80	141	...	...	5
Benzoic,	500	2	3	7	10
Boric,	25	15	...	...	10
Carbolic, Anhyd,	15	a.	a.	a.	a.
Chromic,	v. s.	dec.	dec.	ins.	dec.
Citric,	0.63	1.61	18	50	2
Formic,	v. s.	v. s.	3	...	a.
Gallic,	100	5	40	...	12
Lactic,	a.	a.	a.	ins.	...
Meconic,	sp.	v. s.	...	...	...
Oleic,	ins.	a.	a.	a.	...
Oxalic, cryst.	8.17	6.8	n. ins.	ins.	7.5
Phosphoric, Glacial,	v. s.	v. s.	ins.	...	...
Picric,	86	s.	s.	s.	...
Pyrogallic, (see Pyrogallol),	...	...	...	...	...
Salicylic,	450	2.4	2	80	60
Stearic,	ins.	45	9	s.	...
Succinic,	19	8	79	n. ins.	...
Tannic,	1	0.6	n. ins.	n. ins.	2
Tartaric,	0.8	2.5	250	n. ins.	a.
Valerianic,	30	a.	2	3	a.
Aconitine,	150	5	2	3	...
Alcohol,	a.	...	a.	a.	a.
Amylic,	sp.	a.	a.	...	...
Alum,	9	ins.	ins.	ins.	2.5
Exsiccated,	20	ins.	ins.	ins.	v. s.
Aluminum Hydrate,	ins.	ins.	ins.	ins.	ins.
Sulphate,	1.2	ins.	ins.	ins.	ins.
Ammonium Benzoate,	5	28	ins.	ins.	ins.
Bicarbonate,	8	ins.	...	...	...
Borate,	12	...	...	...	...
Bromide,	1.5	30	600	...	...
Carbonate,	4	dec.	ins.	...	5
Chloride,	3	sp. sol.	ins.	...	5
Iodide,	1	9	ins.	...	...
Nitrate,	0.5	20	...	...	...
Oxalate,	3	...	...	...	...
Phosphate,	4	ins.	...	...	...
Sulphate,	1.3	sp.	...	...	...
Valerianate.	v. s.	v. s.	...	...	...
Amyl Acetate,	ins.	a.	a.	...	...
Nitrite,	ins.	a.	a.	a.	...
Anilin,	sl.	a.	a.	a.	...
Antifebrin, (see Acetanilid),	...	...	...	...	...
Antimony Arseniate.	ins.	ins.	...	...	...
Oxide,	n. ins	ins.	ins.	ins.	...
Sulphide,	ins.	ins.	...	...	...
and Potassium Tartrate,	17	ins.	ins.	20	20
Antipyrin,	1	1	50	...	...
Apocodeine,	ins.	s.	s.	s.	...
Apomorphine Hydrochlorate,	6.8	25	sl.	sl.	...
Aristol,	ins.	sp.	s.	s.	...
Arsenic Bromide,	dec.	...	...	...	...
Iodide,	3.5	10	sol.	...	...
Atropine,	130	3	16	4	50
Hydrochlorate,	v. s.	v. s.	sl.	...	...
Sulphate,	0.4	6.2	2270	694	3
Balsam Peru,	...	5	...	s.	...

* "Era" Formulary.

TABLE OF SOLUBILITIES.—*Continued.*

MEDICINAL SUBSTANCES. One part is soluble in [at 59° F. (15° C.) U. S. P. Standard Temperature.]	PARTS OF Water.	Alcohol.	Ether.	Chloroform.	Glycerin.
Balsam Tolu,	n. ins.	s.	s.	s.	. . .
Barium Acetate,	2	100	. . .	. . .	. . .
Bromide,	v. s.	s.	. . .	. . .	. . .
Carbonate,	ins.	n. ins.	. . .	. . .	. . .
Chloride,	2½	ins.	. . .	. . .	10
Nitrate,	8–12	ins.	. . .	. . .	. . .
Benzanilide,	n. ins.	58	. . .	. . .	. . .
Benzene,	ins.	. . .	s.	s.	. . .
Benzin,	ins.	6	s.	s.	. . .
Bebeerine,	6000	sol.	13	s.	. . .
Hydrochlorate,	s.	s.	. . .	. . .	. . .
Sulphate,	s.	v. s.	. . .	. . .	. . .
Berberine,	500	250	ins.	. . .	. . .
Hydrochlorate,	600	sp.	ins.	. . .	. . .
Bismuth Chloride,	ins.	ins.	. . .	. . .	. . .
Citrate,	ins.	ins.	. . .	. . .	. . .
Oxide,	ins.	ins.	. . .	. . .	. . .
Oxyiodide,	ins.	ins.	. . .	. . .	. . .
Salicylate,	ins.	ins.	ins.	. . .	. . .
Subcarbonate,	ins.	ins.	ins.	. . .	. . .
Subgallate,	ins.	ins.	ins.	. . .	. . .
Subnitrate,	ins.	ins.	. . .	. . .	. . .
Tannate,	ins.	ins.	. . .	. . .	. . .
and Ammonium Citrate,	v. s.	sp.	. . .	. . .	. . .
Bromal Hydrate,	s.	s.	s.	s.	s.
Bromine,	30	s. (dec.)	s. (dec.)	s.	. . .
Bromoform,	v. sp.	s.	s.	. . .	. . .
Brucine,	750	2	ins.	. . .	50
Sulphate,	v. s.	v. s.	. . .	. . .	. . .
Butyl Chloral Hydrate,	50	1	s.	n. ins.	1
Cadmium Acetate,	v. s.	. . .	. . .	. . .	. . .
Chloride,	0.7	s.	. . .	. . .	. . .
Iodide,	2	sol.	. . .	. . .	. . .
Sulphate,	v. s.	v. s.	. . .	. . .	. . .
Caffeine,	80	33	555	7	. . .
Citrate,	30	s.	. . .	. . .	. . .
Phosphate,	. . .	v. s.	. . .	. . .	. . .
Calcium Acetate,	s.	s.	. . .	. . .	. . .
Benzoate,	29	. . .	. . .	. . .	. . .
Bromide,	0.7	1	. . .	. . .	. . .
Carbonate,	ins.	ins.	ins.	ins.	. . .
Chloride,	1½	8	ins.	. . .	. . .
Hypophosphite,	6.8	ins.	. . .	. . .	. . .
Hyposulphite,	1	. . .	. . .	. . .	. . .
Iodide,	½	s.	. . .	. . .	. . .
Lactate,	9–12	s.	ins.	. . .	. . .
Phosphate,	ins.	ins.	ins.	. . .	. . .
Sulphate,	382	ins.	. . .	. . .	. . .
Sulphite,	800	. . .	. . .	. . .	20
Camphor,	sp.	v. s.	v. s.	v. s.	. . .
Monobromated.	n. ins.	6	v. s.	v. s.	sl.
Cannabine Tannate,	sl.	sl.	sl.	. . .	. . .
Carbon Disulphide,	535	v. s.	v. s.	v. s.	. . .
Cerium Acetate,	v. s.	s.	. . .	. . .	. . .
Bromide,	sl.	s.	. . .	. . .	. . .
Nitrate,	s.	s.	. . .	. . .	. . .
Oxalate,	ins.	ins.	ins.	. . .	. . .
Chinoidine,	n. ins.	sp.	s.	s.	. . .
Chloral,	v. s.	v. s.	v. s.	v. s.	s.
Chloroform,	200	s.	s.	. . .	. . .
Chrysarobin,	n. ins.	sp.	s.	. . .	. . .
Cinchonine,	3760	116	526	163	200
Hydrochlorate,	22	1	550	. . .	. . .
Sulphate,	66	10	ins.	78	16
Cinchonidine,	2500	20	80	10	. . .
Hydrochlorate,	27	s.	n. ins.	n. ins.	. . .
Sulphate.	70	66	ins.	1316	. . .
Codeine,	80	3	30	2	. . .
Hydrochlorate,	20	. . .	. . .	. . .	. . .
Sulphate,	35	. . .	. . .	. . .	. . .
Phosphate,	4	sp.	. . .	. . .	. . .
Cocaine,	700	v. s.	v. s.	. . .	. . .
Hydrochlorate,	0.48	3.5	2800	17	. . .

TABLE OF SOLUBILITIES.—*Continued.*

MEDICINAL SUBSTANCES. One part is soluble in [at 59° F. (15° C.) U. S. P. Standard Temperature.]	PARTS OF Water.	Alcohol.	Ether.	Chloroform.	Glycerin.
Coniine,	100	v. s.	6	1	. . .
Hydrobromate,	2	2	s.	s.	. . .
Copper Acetate,	15	16	ins.	. . .	10
Ammoniated,	1½	ins.	. . .	. . .	. . .
Chloride,	v. s.	v. s.	. . .	. . .	. . .
Lactate,	2-6	s.	. . .	. . .	. . .
Nitrate,	s.	s.	. . .	. . .	. . .
Sulphate,	2.6	n. ins.	ins.	. . .	3½
Creosote,	150	s.	s.	s.	. . .
Delphinine,	n. ins.	8	s.	s.	. . .
Digitalin,	1000	s.	ins.	. . .	. . .
Digitin,	s.	. . .	. . .	. . .	. . .
Diuretin,	sl.	. . .	sp.	. . .	. . .
Duboisine,	500	v. s.	s.	s.	. . .
Sulphate,	s.	s.	. . .	. . .	. . .
Elaterin,	4250	337	543	2.4	. . .
Emetine,	2000	s.	sp.	v. s.	. . .
Ergotinine,	ins.	v. s.	v. s.	v. s.	. . .
Ether Acetic,	8	s.	s.	. . .	. . .
Butyric,	sl.	s.	. . .	. . .	. . .
Formic,	sp.	s.	s.	. . .	. . .
Sulphuric,	12	s.	. . .	s.	. . .
Ethyl Bromide,	sp.	s.	s.	. . .	. . .
Iodide,	n. ins.	v. s.	v. s.	. . .	. . .
Eucalyptol,	. . .	s.	. . .	. . .	. . .
Eugenol,	sp.	v. s.	v. s.	. . .	. . .
Euphorin,	sl.	. . .	. . .	. . .	. . .
Europhen,	ins.	. . .	. . .	s.	. . .
Gelseminine,	n. ins.	s.	25	v. s.	. . .
Tartrate,	v. s.	v. s.	. . .	. . .	. . .
Glycerin,	s.	s.	ins.	ins.	. . .
Glycyrrhizin, Ammoniated,	s.	s.	. . .	. . .	. . .
Gold Bromide (mono),	ins.	. . .	. . .	. . .	. . .
(tri),	s.	. . .	. . .	. . .	. . .
Chloride (tri),	s.	s.	s.	. . .	. . .
Iodide,	ins.	ins.	. . .	. . .	. . .
and Sodium Chloride,	2	sp.	. . .	. . .	. . .
Guaiacol,	200	s.	s.	. . .	. . .
Benzoate,	ins.	s.	v. s.	v. s.	. . .
Gutta Percha,	ins.	ins.	. . .	s.	. . .
Hydrastinine,	n. ins.	v. s.	v. s.	v. s.	. . .
Hydrochlorate,	0.3	3	n. ins.	n. ins.	. . .
Hydroquinone,	20	v. s.	v. s.	. . .	. . .
Hyoscine,	sl.	v. s.	v. s.	. . .	. . .
Hydrobromate,	1.9	13	sl.	sl.	. . .
Hydrochlorate,	s.	ins.	ins.	. . .	. . .
Hyoscyamine,	500	v. s.	s.	s.	. . .
Hydrobromate,	0.3	2	3000	250	. . .
Sulphate,	0.5	.5	sl.	sl.	. . .
Hypnone,	n. ins.	v. s.	v. s.	s.	. . .
Ichthyol,	s.	sp.	sp.	s.	s.
Iodine,	5000	10	3	s.	50
Iodoform.,	n. ins.	52	5.2	v. s.	. . .
Iodol,	5000	3	1	. . .	. . .
Iron Acetate,	4	s.	. . .	. . .	. . .
Albuminate,	s.	ins.	. . .	. . .	. . .
Arseniate,	ins.	ins.	. . .	. . .	. . .
Bromide,	s.	s.	. . .	. . .	. . .
Carbonate Saccharated,	sp.	ins.	. . .	. . .	. . .
Chloride (Ferric),	v. s.	v. s.	sl.	. . .	. . .
Citrate,	s.	ins.	ins.	. . .	. . .
Hypophosphite,	n. ins.	. . .	. . .	. . .	. . .
Iodide,	s.	. . .	. . .	. . .	s.
Iodide, Saccharated,	7	n. ins.	. . .	. . .	. . .
Lactate,	40	ins.	ins.	. . .	7
Nitrate,	s.	s.	. . .	. . .	. . .
Oxalate,	n. ins.	ins.	. . .	. . .	. . .
Phosphate (Soluble),	v. s.	ins.	. . .	. . .	. . .
Pyrophosphate,	v. s.	ins.	. . .	. . .	. . .
Santonate,	n. ins.	v. s.	sp.	s.	. . .
Sulphate,	1.8	ins.	ins.	. . .	4
Valerianate,	ins.	v. s.	. . .	. . .	. . .
and Ammonium Chloride,	s.	ins.	. . .	. . .	. . .

TABLE OF SOLUBILITIES.—*Continued.*

MEDICINAL SUBSTANCES. One part is soluble in [at 59° F. (15° C.) U. S. P. Standard Temperature.]	PARTS OF				
	Water.	Alcohol.	Ether.	Chloroform.	Glycerin.
Iron and Ammonium Citrate,	s.	ins.	...	...	...
Ammonium Sulphate,	3	ins.	...	...	...
Ammonium Tartrate,	v. s.	ins.	...	...	13
Potassium Tartrate,	v. s.	ins.	...	...	...
Quinine Citrate,	2-3	sp.	...	...	...
Strychnine Citrate,	s.	sp.	...	...	...
Kairine,	6	20	ins.	...	...
Lead Acetate,	2.3	21	ins.	3	5
Carbonate,	ins.	ins.	...	...	...
Chloride,	140	200	...	...	...
Chromate,	ins.	...	...	...	...
Iodide,	2000	sp.	n. ins.	...	...
Nitrate,	2	n. ins.	...	...	...
Oxide,	n. ins.	ins.	...	...	...
Sulphate,	n. ins.	ins.	...	...	...
Lime,	750	ins.	...	...	65
Chlorinated,	sp.	sp.	...	...	...
Sulphuretted.	sl.	ins.	...	...	20
Lithium Benzoate,	4	12	...	...	...
Bromide,	0.6	v. s.	s.	...	...
Carbonate,	80	ins.	ins.	...	...
Chloride,	1.7	v. s.	...	...	...
Citrate,	2.	n. ins.	ins.	...	s.
Iodide,	0.6	...	...	...	...
Nitrate,	2	...	...	...	...
Salicylate,	v. s.	v. s.	...	...	...
Magnesia,	n. ins.	ins.	...	...	...
Magnesium Acetate,	s.	s.	...	...	...
Benzoate,	v. s.	...	...	...	...
Bromide,	v. s.	s.	...	...	...
Carbonate,	n. ins.	ins.	...	...	...
Chloride,	0.6	...	...	...	...
Lactate,	30	ins.	...	...	...
Phosphate,	350	ins.	...	...	...
Sulphate,	1.5	ins.	ins.	...	...
Sulphite,	40	ins.	ins.	...	...
Tartrate.	122	...	...	...	...
Manganese Benzoate,	20	sp.	...	...	...
Carbonate,	ins.	ins.	...	...	...
Chloride,	2½	s.	ins.	...	...
Dioxide,	ins.	ins.	ins.	...	...
Hypophosphite,	v. s.	...	...	...	...
Iodide,	s.	...	...	...	...
Lactate,	12	s.	...	...	...
Phosphate,	ins.	ins.	...	...	...
Sulphate,	0.8	ins.	ins.	...	...
Mastich,	ins.	sp.	s.	s.	...
Menthol,	sl.	v. s.	v. s.	v. s.	...
Mercury Bisulphate,	333	ins.	ins.	...	...
Chloride, Ammoniated,	ins.	ins.	...	...	...
Corrosive,	16	3	4	...	4
Mild,	ins.	ins	ins.	...	...
Cyanide,	12.8	15	sp.	...	4
Iodide, Green,	n. ins.	ins.	ins.	...	...
Red,	n. ins.	130	ins.	s.	3½
Oxide, Black,	ins.	ins.	...	...	...
Red,	ins.	ins.	...	...	...
Salicylate,	ins.	ins.	...	...	...
Sulphate, Basic,	2000	ins.	...	...	...
Sulphide, Black,	ins.	...	...	...	...
Red,	ins.	ins.	...	...	...
Morphine,	4350	300	4000	160	210
Acetate,	2.5	47.6	1700	2100	5
Hydrobromate,	25	...	...	...	20
Hydrochlorate,	24	62	sl.	sl.	s.
Lactate,	8	93	...	...	...
Meconate,	25	v. s.	...	...	...
Sulphate,	21	702	n. ins.	...	5
Tartrate,	10	v. s.	...	...	...
Naphthalin,	ins.	15	v. s.	v. s.	...
Naphthol (Alpha),	s.	v. s.	v. s.	...	...
(Beta),	1000	0.75	v. s.	v. s.	...
Narceine,	1200	800	ins.	...	...

TABLE OF SOLUBILITIES.—*Continued.*

MEDICINAL SUBSTANCES. One part is soluble in [at 59° F. (15° C.) U. S. P. Standard Temperature.]	PARTS OF				
	Water.	Alcohol.	Ether.	Chloroform.	Glycerin.
Narceine, Hydrochlorate,	s.	v. s.	. . .	. . .	. . .
Narcotine,	n. ins.	80	35	3	. . .
Nickel Acetate,	6	ins.	. . .	. . .	. . .
Bromide,	s.	s.	s.	. . .	. . .
Nitrate,	2	s.	. . .	. . .	. . .
Phosphate,	ins.	. . .	. . .	. . .	. . .
Sulphate,	4	ins.	ins.	. . .	. . .
Nicotine,	v. s.	v. s.	s.	s.	. . .
Hydrochlorate,	v. s.	v. s.	ins.	. . .	. . .
Nitroglycerin,	n. ins.	v. s.	s.	. . .	. . .
Orexin,	. . .	s.	. . .	. . .	. . .
Pancreatin,	s.	ins.	. . .	. . .	. . .
Papaverine,	ins.	sp.	s.	s.	. . .
Paraffin,	ins.	ins.	s.	s.	. . .
Paraldehyde,	8.5	s.	s.	. . .	. . .
Pelletierine,	v. s.	v. s.	v. s.	v. s.	. . .
Tannate,	700	80	. . .	. . .	. . .
Pepsin,	100	ins.	ins.	ins.	. . .
Petrolatum,	ins.	ins.	s.	s.	. . .
Phenacetin,	sp.	16	. . .	. . .	s.
Phenocoll Hydrochlorate,	16	. . .	. . .	. . .	. . .
Phenyl Hydrazine,	sp.	v. s.	v. s.	. . .	. . .
Phosphorus,	ins.	s.	80	v. s.	500
Physostigmine,	sp.	v. s.	v. s.	s.	. . .
Salicylate,	130	12	. . .	. . .	. . .
Sulphate,	s.	. . .	. . .	. . .	. . .
Picrotoxin,	240	9	sl.	sl.	. . .
Pilocarpine,	s.	v. s.	s.	s.	. . .
Hydrochlorate,	v. s.	v. s.	n. ins.	n. ins.	. . .
Hydrobromate,	s.	s.	. . .	s.	. . .
Nitrate,	9	40	s.	. . .	. . .
Sulphate,	s.	s.	s.	s.	. . .
Piperazine,	v. s.	. . .	. . .	. . .	. . .
Piperin,	n. ins.	30	sl.	s.	. . .
Podophyllin,	n. ins.	s.	sp.	. . .	. . .
Potassa, Sulphurated,	2	sp.	. . .	. . .	. . .
Potassium Acetate,	0.36	1.9	ins.	. . .	. . .
Arseniate,	5.8	25	. . .	. . .	2
Arsenite,	v. s.	sp.	. . .	. . .	. . .
Benzoate,	v. s.	. . .	. . .	. . .	. . .
Bicarbonate,	3.2	n. ins.	ins.	. . .	. . .
Bichromate,	10	ins.	ins.	. . .	. . .
Bisulphate,	2	ins.	. . .	. . .	. . .
Bisulphite,	v. s.	. . .	. . .	. . .	. . .
Bitartrate,	201	sp.	ins.	. . .	. . .
Bromide,	1.6	200	ins.	. . .	4
Carbonate,	1.1	ins.	ins.	. . .	. . .
Chlorate,	16.7	sp.	ins.	. . .	30
Chloride,	3	s.	ins.	. . .	30
Citrate,	0.6	sp.	. . .	. . .	. . .
Cyanide,	2	sp.	. . .	. . .	3.5
Ferricyanide,	4	sp.	. . .	. . .	. . .
Ferrocyanide,	4	ins.	. . .	. . .	. . .
Hydrate,	0.5	2	sl.	. . .	. . .
Hypophosphite,	0.6	7.3	. . .	. . .	. . .
Iodide,	0.75	18	ins.	. . .	2.5
Nitrate,	3.8	sp.	ins.	. . .	. . .
Nitrite,	v. s.	. . .	. . .	. . .	. . .
Oxalate,	s.	. . .	. . .	. . .	. . .
Permanganate.	16	dec.	ins.	. . .	. . .
Phosphate,	s.	. . .	. . .	. . .	. . .
Salicylate,	s.	s.	ins.	. . .	. . .
Sulphate,	9.5	ins.	ins.	. . .	. . .
Tartrate,	1	ins.	ins.	. . .	. . .
and Sodium Tartrate,	1.4	n. ins.	ins.	. . .	. . .
Pyoktanin,	75	12	ins.	s.	50
Pyridine,	s.	v. s.	v. s.	. . .	. . .
Nitrate,	v. s.	sp.	. . .	. . .	. . .
Sulphate,	v. s.	v. s.	. . .	. . .	. . .
Pyrodine Hydrochlorate,	sp.	v. s.	ins.	. . .	. . .
Pyrogallol,	1.7	1	1.2	. . .	. . .
Quinidine,	2000	20	30	. . .	. . .
Hydrochlorate,	27	v. s.	ins.	. . .	. . .

TABLE OF SOLUBILITIES.—*Continued.*

MEDICINAL SUBSTANCES. One part is soluble in [at 59° F. (15° C.) U. S. P. Standard Temperature.]	PARTS OF				
	Water.	Alcohol.	Ether.	Chloroform.	Glycerin.
Quinidine Sulphate,	100	8	n. ins.	14	. . .
Quinine,	1670	6	23	5	200
Acetate,	600	7	. . .	. . .	. . .
Arseniate,	sp.	. . .	. . .	. . .	. . .
Arsenite,	sp.	15	25	8	. . .
Benzoate,	350	. . .	. . .	. . .	. . .
Bisulphate,	10	32	ins.	. . .	. . .
Hydrobromate,	54	0.6	6	12	s.
Hydrochlorate,	34	3	ins.	9	. . .
Hypophosphite,	45	10	. . .	. . .	. . .
Lactate,	3	s.	. . .	. . .	. . .
Phosphate,	700	sl.	. . .	. . .	. . .
Salicylate,	225	20	120	v. s.	. . .
Sulphate,	740	65	sl.	680	40
Tannate,	n. ins.	sl.	. . .	. . .	135
Valerianate,	100	5	s.	. . .	. . .
Quinoline Nitrate,	v. s.	v. s.	ins.	. . .	. . .
Salicylate,	100	. . .	. . .	. . .	. . .
Tartrate,	s.	. . .	. . .	. . .	. . .
Resin,	ins.	s.	s.	s.	. . .
Resorcin,	0.6	0.5	v. s.	sl.	v. s.
Retinol,	ins.	ins.	sol.	. . .	. . .
Saccharin,	290	30	0.3	. . .	s.
Salicin,	28	30	n. ins.	n. ins.	. . .
Salol,	n. ins.	10	0.3	v. s.	. . .
Sanguinarine,	ins.	v. s.	v. s.	s.	. . .
Nitrate.	n. ins.	. . .	. . .	. . .	. . .
Sulphate,	s.	s.	. . .	. . .	. . .
Santonin,	5000	40	140	4	. . .
Scoparine,	n. ins.	s.	. . .	. . .	. . .
Silver Acetate,	100	sp.	. . .	. . .	. . .
Bromide,	ins.	. . .	. . .	. . .	. . .
Chloride,	ins.	. . .	. . .	. . .	. . .
Cyanide,	ins.	ins.	. . .	. . .	. . .
Iodide,	ins.	ins.	. . .	. . .	. . .
Nitrate,	0.6	26	. . .	. . .	. . .
Oxide,	n. ins.	ins.	. . .	. . .	. . .
Sulphate,	200	. . .	. . .	. . .	. . .
Sodium Acetate,	1.4	30	ins.	. . .	. . .
Arsenate,	4	sp.	. . .	. . .	2
Arsenite,	s.	sp.	. . .	. . .	. . .
Benzoate,	1.8	45	ins.	. . .	. . .
Bicarbonate,	11.3	ins.	ins.	. . .	13
Bisulphite,	4	72	. . .	. . .	. . .
Borate,	16	ins.	ins.	. . .	2
Bromide,	1.2	13	ins.	. . .	. . .
Carbonate,	1.6	ins.	ins.	. . .	1.02
Chlorate,	1.1	100	. . .	. . .	5
Chloride,	2.8	n. ins.	ins.	ins.	5
Citrate,	v. s.	. . .	. . .	. . .	. . .
Formate,	s.	. . .	. . .	. . .	s.
Hydrate,	1.7	v. s.	. . .	. . .	. . .
Hypophosphite,	1	30	ins.	. . .	. . .
Hyposulphite,	0 65	ins.	. . .	. . .	. . .
Iodide,	0.6	3	ins.	. . .	. . .
Lactate,	v. s.	v. s.	ins.	. . .	. . .
Nitrate,	1.3	100	ins.	. . .	. . .
Nitrite,	1.5	sl.	. . .	. . .	. . .
Phosphate,	5.8	ins.	ins.	. . .	. . .
Pyrophosphate,	12	ins.	. . .	. . .	. . .
Salicylate,	0.9	6	ins.	. . .	s.
Santoninate,	3	12	ins.	. . .	. . .
Sulphate,	2.8	ins.	ins.	. . .	s.
Sulphide,	v. s.	sl.	. . .	. . .	. . .
Sulphite,	4	sp.	. . .	. . .	. . .
Sulphocarbolate,	4.8	132	. . .	. . .	. . .
Tartrate,	5	ins.	. . .	. . .	. . .
Valerianate,	v. s.	s.	. . .	. . .	. . .
Solanine,	ins.	400	sl.	. . .	. . .
Sozal,	v. s.	v. s.	. . .	. . .	s.
Sparteine,	sp.	v. s.	v. s.	v. s.	. . .
Sulphate,	v. s.	v. s.	. . .	. . .	. . .
Spermaceti,	ins.	n. ins.	s.	s.	. . .

TABLE OF SOLUBILITIES.—*Continued.*

MEDICINAL SUBSTANCES. One part is soluble in [at 59° F. (15° C.) U. S. P. Standard Temperature.]	PARTS OF				
	Water.	Alcohol.	Ether.	Chloroform.	Glycerin.
Strontium Bromide,	1.05	s.	. . .	. . .	. . .
Carbonate,	sl.	. . .	. . .	. . .	. . .
Chloride,	2	20	. . .	. . .	. . .
Iodide,	0.6	s.	sl.	. . .	. . .
Lactate,	4	s.	. . .	. . .	. . .
Nitrate,	5	ins.	. . .	. . .	. . .
Sulphate,	sl.	ins.	. . .	. . .	. . .
Strophanthin,	s.	s.	ins.	. . .	. . .
Strychnine,	6700	110	ins.	7	400
Acetate,	75	. . .	. . .	15	. . .
Hydrobromate,	32	sp.	. . .	. . .	. . .
Hydrochlorate,	50	. . .	. . .	. . .	. . .
Nitrate,	75	100	ins.	. . .	30
Sulphate,	50	109	ins.	. . .	5
Sugar, Cane,	0.5	175	ins.	ins.	s.
Milk,	6	ins.	ins.	ins.	. . .
Sulphonal,	500	65	125	. . .	. . .
Sulphur Iodide,	ins.	sp.	sp.	. . .	60
Precipitated,	ins.	ins.	s.	s.	. . .
Sublimed,	ins.	ins.	s.	s.	. . .
Washed,	ins.	ins.	s.	s.	. . .
Terebene,	sl.	s.	. . .	. . .	. . .
Terpin Hydrate,	250	10	10	200	. . .
Terpinol,	ins.	s.	s.	. . .	. . .
Tetronal,	sl.	v. s.	s.	. . .	. . .
Thalline Sulphate,	7	100	sl.	sl.	. . .
Tartrate,	10	sp.	n. ins.	. . .	. . .
Trimethylamine,	s.	s.	. . .	. . .	. . .
Hydrochlorate,	s.	s.	. . .	. . .	. . .
Trional,	320	v. s.	v. s.	. . .	. . .
Thymol,	1200	1	0.8	0.7	120
Uranium Acetate,	10	sl.	. . .	. . .	. . .
Chloride,	s.	. . .	. . .	. . .	. . .
Nitrate,	v. s.	v. s.	4	. . .	. . .
Urea,	1	ins.	ins.	. . .	2
Urethane,	s.	s.	s.	. . .	. . .
Urexine,	sp.	. . .	. . .	s.	. . .
Vanilla,	sp.	s.	s.	s.	. . .
Veratrine,	sl.	3	6	2	. . .
Hydrochlorate,	v. s.	v. s.	. . .	. . .	. . .
Zinc Acetate,	2.7	36	ins.	. . .	. . .
Bromide,	v. s.	v. s.	. . .	. . .	. . .
Carbonate, Precipitated,	ins.	ins.	. . .	. . .	. . .
Chloride,	0.3	v. s.	s.	. . .	2
Cyanide,	ins.	ins.	. . .	. . .	. . .
Iodide,	v. s.	v. s.	v. s.	. . .	2.5
Lactate,	60	ins.	. . .	. . .	. . .
Nitrate,	v. s.	s.	. . .	. . .	. . .
Oxide,	ins.	ins.	. . .	. . .	. . .
Permanganate,	v. s.	v. s.	. . .	. . .	explodes.
Phosphate,	ins.	ins.	. . .	. . .	. . .
Phosphide,	ins.	ins.	. . .	. . .	. . .
Salicylate,	25	3.5	36	. . .	. . .
Sulphate,	0.6	ins.	ins.	. . .	3
Tannate,	ins.	ins.	. . .	. . .	. . .
Valerianate,	100	40	n. ins.	. . .	. . .

LIST OF THE PRINCIPAL PHARMACOPŒIAL CHEMICALS AND REAGENTS.*

Acetanilid,	$C_6H_5NH.C_2H_3O$	134.73
Acid, Acetic,	$HC_2H_3O_2$	59.86
" Arsenous,	As_2O_3	197.68
" Aurochloric,	$HAuCl_4 + 2H_2O$	375.10
" Benzoic,	$HC_7H_5O_2$	121.71
" Boric,	H_3BO_3	61.78
" Carbolic,	C_6H_5OH	93.78
" Chloroplatinic,	$H_2PtCl_6 + 6H_2O$	516.28
" Chromic,	CrO_3	99.88
" Citric,	$H_3C_6H_5O_7 + H_2O$	209.50
" " dry,	$H_3C_6H_5O_7$	191.54
" Gallic,	$HC_7H_5O_5 + H_2O$	187.55
" " dry,	$HC_7H_5O_5$	169.59
" Hydriodic,	HI	127.53
" Hydrobromic,	HBr	80.76
" Hydrochloric,	HCl	36.37
" Hydrocyanic,	HCN	26.98
" Hydrosulphuric (See Hydrogen Sulphide).		
" Hypophosphorous,	HPH_2O_2	65.88
" Lactic,	$HC_3H_5O_3$	89.79
" Nitric,	HNO_3	62.89
" Oleic,	$HC_{18}H_{33}O_2$	281.38
" Oxalic,	$H_2C_2O_4 + 2H_2O$	125.70
" " dry,	$H_2C_2O_4$	89.78
" Phosphoric,	H_3PO_4	97.80
" Picric,	$C_6H_2(NO_2)_3OH$	228.57
" Pyroboric,	$H_2B_4O_7$	157.32
" Pyrogallic (See Pyrogallol).		
" Salicylic,	$HC_7H_5O_3$	137.67
" Stearic,	$HC_{18}H_{35}O_2$	283.38
" Sulphuric,	H_2SO_4	97.82
" Sulphurous,	H_2SO_3	81.86
" Tannic,	$HC_{14}H_9O_9$	321.22
" Tartaric,	$H_2C_4H_4O_6$	149.64
" Tetraboric (See Pyroboric).		
Alcohol, ethylic,	C_2H_5OH	45.90
" methylic,	CH_3OH	31.93
Aldehyde, ethylic,	C_2H_4O	43.90
Alum (See Aluminum and Potassium Sulphate).		
Aluminum Hydrate,	$Al_2(OH)_6$	155.84
" and Potassium Sulphate,	$Al_2K_2(SO_4)_4 + 24H_2O$	946.46
" " " " dry,	$Al_2K_2(SO_4)_4$	515.42
" Sulphate,	$Al_2(SO_4)_3 + 16H_2O$	628.90
" " dry,	$Al_2(SO_4)_3$	341.54
Ammonia,	NH_3	17.01
Ammonium Acetate,	$NH_4C_2H_3O_2$	76.87

* U. S. Pharmacopœia, 1890.

APPENDIX.

TABLE OF ATOMIC WEIGHTS.

According to L. Meyer and K. Seubert.

Name.	Symbol.	Atomic Weight.	Name.	Symbol.	Atomic Weight.
Aluminum,	Al	27.04	Molybdenum,	Mo	95.9
Antimony,	Sb	119.6	Nickel,	Ni	58.6
Arsenic,	As	74.9	Nitrogen,	N	14.01
Barium,	Ba	136.9	Osmium,	Os	190.3
Beryllium,*	Be	9.03	Oxygen,	O	15.96
Bismuth,	Bi	208.9	Palladium,	Pd	106.35
Boron,	B	10.9	Phosphorus,	P	30.96
Bromine,	Br	79.76	Platinum,	Pt	194 3
Cadmium,	Cd	111.5	Potassium,	K	39.03
Cæsium,	Cs	132.7	Rhodium,	Rh	102.9
Calcium,	Ca	39.91	Rubidium,	Rb	85.2
Carbon,	C	11.97	Ruthenium,	Ru	101.4
Cerium,	Ce	139.9	Samarium,	Sm	149.62
Chlorine,	Cl	35.37	Scandium,	Sc	43.97
Chromium,	Cr	52.0	Selenium,	Se	78.87
Cobalt,	Co	58.6	Silicon,	Si	28.3
Columbium,†	Cb	93.7	Silver,	Ag	107.66
Copper,	Cu	63.18	Sodium,	Na	23.0
Didymium,‡	Di	142.0	Strontium,	Sr	87.3
Erbium,	Er	166.0	Sulphur,	S	31.98
Fluorine,	F	19.0	Tantalum,	Ta	182.0
Gallium,	Ga	69.9	Tellurium,	Te	125.0
Germanium,	Ge	72.3	Terbium,	Tb	159.1
Gold,	Au	196.7	Thallium,	Tl	203.7
Hydrogen,	H	1.0	Thorium,	Th	231.9
Indium,	In	113.6	Tin,	Sn	118.8
Iodine,	I	126.53	Titanium,	Ti	48.0
Iridium,	Ir	192.5	Tungsten,	W	183.6
Iron,	Fe	55.88	Uranium,	U	238.8
Lanthanum,	La	138.2	Vanadium,	V	51.1
Lead,	Pb	206.4	Ytterbium,	Yb	172.6
Lithium,	Li	7.01	Yttrium,	Yt	88.9
Magnesium,	Mg	24 3	Zinc,	Zn	65.1
Manganese,	Mn	54.8	Zirconium,	Zr	90.4
Mercury,	Hg	199.8			

* Also called Glucinum, Gl = 9.03.
† Also called Niobium, Nb = 93.7.
‡ Composed of Neo- and Praseo-Didymium.

TABLE OF SOLUBILITIES.*

IN WATER, ALCOHOL, ETHER, CHLOROFORM AND GLYCERIN, OF MEDICINAL SUBSTANCES OFFICIAL IN THE U. S. PHARMACOPŒIA, INCLUDING MANY OTHERS OF COMMON OR FREQUENT USE.

ABBREVIATIONS—*s.*, soluble; *v. s.*, very soluble; *sp.*, sparingly; *a.*, all proportions; *sl.*, slightly; *ins.*, insoluble; *n. ins.*, nearly insoluble; *dec.*, decomposed.

MEDICINAL SUBSTANCES. One part is soluble in [at 59° F (15° C.) U. S. P. Standard Temperature.]	PARTS OF				
	Water.	Alcohol.	Ether.	Chloroform.	Glycerin.
Acacia,	2	ins.	...	...	...
Acetanilid,	194	5	18	v. s.	...
Acid, Arsenic,	2	...	...	...	5
Arsenous,	80	141	...	...	5
Benzoic,	500	2	3	7	10
Boric,	25	15	...	...	10
Carbolic, Anhyd,	15	a.	a.	a.	a.
Chromic,	v. s.	dec.	dec.	ins.	dec.
Citric,	0.63	1.61	18	50	2
Formic,	v. s.	v. s.	3	...	s.
Gallic,	100	5	40	...	12
Lactic,	a.	a.	a.	ins.	...
Meconic,	sp.	v. s.	...	...	...
Oleic,	ins.	a.	a.	a.	...
Oxalic, cryst.	8.17	6.8	n. ins.	ins.	7.5
Phosphoric, Glacial,	v. s.	v. s.	ins.	...	...
Picric,	86	s.	s.	s.	...
Pyrogallic, (see Pyrogallol),	...	...	...	...	...
Salicylic,	450	2.4	2	80	60
Stearic,	ins.	45	9	s.	...
Succinic,	19	8	79	n. ins.	...
Tannic,	1	0.6	n. ins.	n. ins.	2
Tartaric,	0.8	2.5	250	n. ins.	a.
Valerianic,	30	a.	2	3	s.
Aconitine,	150	5	2	3	...
Alcohol,	a.	...	a.	a.	a.
Amylic,	sp.	a.	a.	...	...
Alum,	9	ins.	ins.	ins.	2.5
Exsiccated,	20	ins.	ins.	ins.	v. s.
Aluminum Hydrate,	ins.	ins.	ins.	ins.	ins.
Sulphate,	1.2	ins.	ins.	ins.	ins.
Ammonium Benzoate,	5	28	ins.	ins.	ins.
Bicarbonate,	8	ins.	...	...	...
Borate,	12	..	...	...	...
Bromide,	1.5	30	600	...	...
Carbonate,	4	dec.	ins.	...	5
Chloride,	3	sp. sol.	ins.	...	5
Iodide,	1	9	ins.	...	...
Nitrate,	0.5	20	...	...	...
Oxalate,	3	...	...	...	...
Phosphate,	4	ins.	...	...	...
Sulphate,	1.3	sp.	...	...	...
Valerianate.	v. s.	v. s.	...	...	...
Amyl Acetate,	ins.	a.	a.	...	...
Nitrite,	ins.	a.	a.	a.	...
Anilin,	sl.	a.	a.	a.	...
Antifebrin, (see Acetanilid),	...	...	...	...	...
Antimony Arseniate.	ins.	ins.	...	...	...
Oxide,	n. ins	ins.	ins.	ins.	...
Sulphide,	ins.	ins.	...	...	...
and Potassium Tartrate,	17	ins.	ins.	20	20
Antipyrin,	1	1	50	...	...
Apocodeine,	ins.	a.	s.	a.	...
Apomorphine Hydrochlorate,	6.8	25	sl.	sl.	...
Aristol,	ins.	sp.	s.	s.	...
Arsenic Bromide,	dec.	...	...	...	...
Iodide,	3.5	10	sol.	...	...
Atropine,	130	3	16	4	50
Hydrochlorate,	v. s.	v. s.	sl.	...	...
Sulphate,	0.4	6.2	2270	694	3
Balsam Peru,	...	5	...	s.	...

* "Era" Formulary.

TABLE OF SOLUBILITIES.—*Continued.*

MEDICINAL SUBSTANCES. One part is soluble in [at 59° F. (15° C.) U. S. P. Standard Temperature.]	PARTS OF				
	Water.	Alcohol.	Ether.	Chloroform.	Glycerin.
Balsam Tolu,	n. ins.	s.	s.	s.	...
Barium Acetate,	2	100	...	...	...
Bromide,	v. s.	s.	...	...	...
Carbonate,	ins.	n. ins.	...	...	...
Chloride,	2½	ins.	...	...	10
Nitrate,	8–12	ins.	...	...	...
Benzanilide,	n. ins.	58	...	...	...
Benzene,	ins.	...	s.	s.	...
Benzin,	ins.	6	s.	s.	...
Bebeerine,	6000	sol.	13	s.	...
Hydrochlorate,	s.	s.	...	...	...
Sulphate,	s.	v. s.	...	...	...
Berberine,	500	250	ins.	...	...
Hydrochlorate,	600	sp.	ins.	...	...
Bismuth Chloride,	ins.	ins.	...	...	...
Citrate,	ins.	ins.	...	...	...
Oxide,	ins.	ins.	...	...	...
Oxyiodide,	ins.	ins.	...	...	...
Salicylate,	ins.	ins.	ins.	...	...
Subcarbonate,	ins.	ins.	ins.	...	...
Subgallate,	ins.	ins.	ins.	...	...
Subnitrate,	ins.	ins.	...	...	...
Tannate,	ins.	ins.	...	...	...
and Ammonium Citrate,	v. s.	sp.	...	...	...
Bromal Hydrate,	s.	s.	s.	s.	s.
Bromine,	30	s. (dec.)	s. (dec.)	s.	...
Bromoform,	v. sp.	s.	s.	...	...
Brucine,	750	2	ins.	...	50
Sulphate,	v. s.	v. s.	...	...	...
Butyl-Chloral Hydrate,	50	1	s.	n. ins.	1
Cadmium Acetate,	v. s.	...	...	...	...
Chloride,	0.7	s.	...	...	...
Iodide,	2	sol.	...	...	...
Sulphate,	v. s.	v. s.	...	...	...
Caffeine,	80	33	555	7	...
Citrate,	30	s.	...	...	...
Phosphate,	...	v. s.	...	...	...
Calcium Acetate,	s.	s.	...	...	...
Benzoate,	29	...	...	...	...
Bromide,	0.7	1	...	...	...
Carbonate,	ins.	ins.	ins.	ins.	...
Chloride,	1½	8	ins.	...	...
Hypophosphite,	6.8	ins.	...	...	...
Hyposulphite,	1	...	...	...	...
Iodide,	½	s.	...	...	...
Lactate,	9–12	s.	ins.	...	...
Phosphate,	ins.	ins.	ins.	...	...
Sulphate,	382	ins.	...	...	...
Sulphite,	800	...	...	...	20
Camphor,	sp.	v. s.	v. s.	v. s.	...
Monobromated.	n. ins.	6	v. s.	v. s.	sl.
Cannabine Tannate,	sl.	sl.	sl.	...	...
Carbon Disulphide,	535	v. s.	v. s.	v. s.	...
Cerium Acetate,	v. s.	s.	...	...	...
Bromide,	sl.	s.	...	...	...
Nitrate,	s.	s.	...	...	...
Oxalate,	ins.	ins.	ins.	...	...
Chinoidine,	n. ins.	sp.	s.	s.	...
Chloral,	v. s.	v. s.	v. s.	v. s.	s.
Chloroform,	200	s.	s.	...	...
Chrysarobin,	n. ins.	sp.	s.	...	...
Cinchonine,	3760	116	526	163	200
Hydrochlorate,	22	1	550	...	...
Sulphate,	66	10	ins.	78	16
Cinchonidine,	2500	20	80	10	...
Hydrochlorate,	27	s.	n. ins.	n. ins.	...
Sulphate.	70	66	ins.	1316	...
Codeine,	80	3	30	2	...
Hydrochlorate,	20	...	...	...	...
Sulphate,	35	...	...	...	...
Phosphate,	4	sp.	...	...	...
Cocaine,	700	v. s.	v. s.	...	...
Hydrochlorate,	0.48	3.5	2800	17	...

TABLE OF SOLUBILITIES.—*Continued.*

MEDICINAL SUBSTANCES. One part is soluble in [at 59° F. (15° C.) U. S. P. Standard Temperature.]	PARTS OF Water.	Alcohol.	Ether.	Chloroform.	Glycerin.
Coniine,	100	v. s.	6	1	. . .
Hydrobromate,	2	2	s.	s.	. . .
Copper Acetate,	15	16	ins.	. . .	10
Ammoniated,	1½	ins.	. . .	. . .	. . .
Chloride,	v. s.	v. s.	. . .	. . .	. . .
Lactate,	2-6	s.	. . .	. . .	. . .
Nitrate,	s.	s.	. . .	. . .	. . .
Sulphate,	2.6	n. ins.	ins.	. . .	3½
Creosote,	150	s.	s.	s.	. . .
Delphinine,	n. ins.	8	s.	s.	. . .
Digitalin,	1000	s.	ins.	. . .	. . .
Digitin,	s.	. . .	. . .	. . .	. . .
Diuretin,	sl.	. . .	sp.	. . .	. . .
Duboisine,	500	v. s.	s.	s.	. . .
Sulphate,	s.	s.	. . .	. . .	. . .
Elaterin,	4250	337	543	2.4	. . .
Emetine,	2000	s.	sp.	v. s.	. . .
Ergotinine,	ins.	v. s.	v. s.	v. s.	. . .
Ether Acetic,	8	s.	s.	. . .	. . .
Butyric,	sl.	s.	. . .	. . .	. . .
Formic,	sp.	s.	s.	. . .	. . .
Sulphuric,	12	s.	. . .	s.	. . .
Ethyl Bromide,	sp.	s.	s.	. . .	. . .
Iodide,	n. ins.	v. s.	v. s.	. . .	. . .
Eucalyptol,	. . .	s.	. . .	. . .	. . .
Eugenol,	sp.	v. s.	v. s.	. . .	. . .
Euphorin,	sl.	. . .	. . .	. . .	. . .
Europhen,	ins.	. . .	. . .	s.	. . .
Gelseminine,	n. ins.	s.	25	v. s.	. . .
Tartrate,	v. s.	v. s.	. . .	. . .	. . .
Glycerin,	s.	s.	ins.	ins.	. . .
Glycyrrhizin, Ammoniated,	s.	s.	. . .	. . .	. . .
Gold Bromide (mono),	ins.	. . .	. . .	. . .	. . .
(tri),	s.	. . .	. . .	. . .	. . .
Chloride (tri),	s.	s.	s.	. . .	. . .
Iodide,	ins.	ins.	. . .	. . .	. . .
and Sodium Chloride,	2	sp.	. . .	. . .	. . .
Guaiacol,	200	s.	s.	. . .	. . .
Benzoate,	ins.	s.	v. s.	v. s.	. . .
Gutta Percha,	ins.	ins.	. . .	s.	. . .
Hydrastinine,	n. ins.	v. s.	v. s.	v. s.	. . .
Hydrochlorate,	0.3	3	n. ins.	n. ins.	. . .
Hydroquinone,	20	v. s.	v. s.	. . .	. . .
Hyoscine,	sl.	v. s.	v. s.	. . .	. . .
Hydrobromate,	1.9	13	sl.	sl.	. . .
Hydrochlorate,	s.	ins.	ins.	. . .	. . .
Hyoscyamine,	500	v. s.	s.	s.	. . .
Hydrobromate,	0.3	2	3000	250	. . .
Sulphate,	0.5	.5	sl.	sl.	. . .
Hypnone,	n. ins.	v. s.	v. s.	s.	. . .
Ichthyol,	s.	sp.	sp.	s.	s.
Iodine,	5000	10	3	s.	50
Iodoform.,	n. ins.	52	5.2	v. s.	. . .
Iodol,	5000	3	1	. . .	. . .
Iron Acetate,	4	s.	. . .	. . .	. . .
Albuminate,	s.	ins.	. . .	. . .	. . .
Arseniate,	ins.	ins.	. . .	. . .	. . .
Bromide,	s.	s.	. . .	. . .	. . .
Carbonate Saccharated,	sp.	ins.	. . .	. . .	. . .
Chloride (Ferric),	v. s.	v. s.	sl.	. . .	. . .
Citrate,	s.	ins.	ins.	. . .	. . .
Hypophosphite,	n. ins.	. . .	. . .	. . .	. . .
Iodide,	s.	. . .	. . .	. . .	s.
Iodide, Saccharated,	7	n. ins.	. . .	. . .	. . .
Lactate,	40	ins.	ins.	. . .	7
Nitrate,	s.	s.	. . .	. . .	. . .
Oxalate,	n. ins.	ins.	. . .	. . .	. . .
Phosphate (Soluble),	v. s.	ins.	. . .	. . .	. . .
Pyrophosphate,	v. s.	ins.	. . .	. . .	. . .
Santonate,	n. ins.	v. s.	sp.	s.	. . .
Sulphate,	1.8	ins.	ins.	. . .	4
Valerianate,	ins.	v. s.	. . .	. . .	. . .
and Ammonium Chloride,	s.	ins.	. . .	. . .	. . .

TABLE OF SOLUBILITIES.—*Continued.*

MEDICINAL SUBSTANCES. One part is soluble in [at 59° F. (15° C.) U. S. P. Standard Temperature.]	PARTS OF				
	Water.	Alcohol.	Ether.	Chloroform.	Glycerin.
Iron and Ammonium Citrate,	s.	ins.	. . .	. . .	. . .
Ammonium Sulphate,	3	ins.	. . .	. . .	. . .
Ammonium Tartrate,	v. s.	ins.	. . .	. . .	13
Potassium Tartrate,	v. s.	ins.	. . .	. . .	. . .
Quinine Citrate,	2-3	sp.	. . .	. . .	. . .
Strychnine Citrate,	s.	sp.	. . .	. . .	. . .
Kairine,	6	20	ins.	. . .	. . .
Lead Acetate,	2.3	21	ins.	3	5
Carbonate,	ins.	ins.	. . .	. . .	. . .
Chloride,	140	200	. . .	. . .	. . .
Chromate,	ins.	. . .	. . .	. . .	. . .
Iodide,	2000	sp.	n. ins.	. . .	. . .
Nitrate,	2	n. ins.	. . .	. . .	. . .
Oxide,	n. ins.	ins.	. . .	. . .	. . .
Sulphate,	n. ins.	ins.	. . .	. . .	. . .
Lime,	750	ins.	. . .	. . .	65
Chlorinated,	sp.	sp.	. . .	. . .	. . .
Sulphuretted,	sl.	ins.	. . .	. . .	20
Lithium Benzoate,	4	12	. . .	. . .	. . .
Bromide,	0.6	v. s.	s.	. . .	. . .
Carbonate,	80	ins.	ins.	. . .	. . .
Chloride,	1.7	v. s.	. . .	. . .	. . .
Citrate,	2.	n. ins.	ins.	. . .	s.
Iodide,	0.6	. . .	. . .	. . .	. . .
Nitrate,	2	. . .	. . .	. . .	. . .
Salicylate,	v. s.	v. s.	. . .	. . .	. . .
Magnesia,	n. ins.	ins.	. . .	. . .	. . .
Magnesium Acetate,	s.	s.	. . .	. . .	. . .
Benzoate,	v. s.	. . .	. . .	. . .	. . .
Bromide,	v. s.	s.	. . .	. . .	. . .
Carbonate,	n. ins.	ins.	. . .	. . .	. . .
Chloride,	0.6	. . .	. . .	. . .	. . .
Lactate,	30	ins.	. . .	. . .	. . .
Phosphate,	350	ins.	. . .	. . .	. . .
Sulphate,	1.5	ins.	ins.	. . .	. . .
Sulphite,	40	ins.	ins.	. . .	. . .
Tartrate.	122	. . .	. . .	. . .	. . .
Manganese Benzoate,	20	sp.	. . .	. . .	. . .
Carbonate,	ins.	ins.	. . .	. . .	. . .
Chloride,	2½	s.	ins.	. . .	. . .
Dioxide,	ins.	ins.	ins.	. . .	. . .
Hypophosphite,	v. s.	. . .	. . .	. . .	. . .
Iodide,	s.	. . .	. . .	. . .	. . .
Lactate,	12	s.	. . .	. . .	. . .
Phosphate,	ins.	ins.	. . .	. . .	. . .
Sulphate,	0 8	ins.	ins.	. . .	. . .
Mastich,	ins.	sp.	s.	s.	. . .
Menthol,	sl.	v. s.	v. s.	v. s.	. . .
Mercury Bisulphate,	333	ins.	ins.	. . .	. . .
Chloride, Ammoniated,	ins.	ins.	. . .	. . .	. . .
Corrosive,	16	3	4	. . .	4
Mild,	ins.	ins	ins.	. . .	. . .
Cyanide,	12.8	15	sp.	. . .	4
Iodide, Green,	n. ins.	ins.	ins.	. . .	. . .
Red,	n. ins.	130	ins.	s.	3½
Oxide, Black,	ins.	ins.	. . .	. . .	. . .
Red,	ins.	ins.	. . .	. . .	. . .
Salicylate,	ins.	ins.	. . .	. . .	. . .
Sulphate, Basic,	2000	ins.	. . .	. . .	. . .
Sulphide, Black,	ins.	. . .	. . .	. . .	. . .
Red,	ins.	ins.	. . .	. . .	. . .
Morphine,	4350	300	4000	160	210
Acetate,	2.5	47.6	1700	2100	5
Hydrobromate,	25	. . .	. . .	. . .	20
Hydrochlorate,	24	62	sl.	sl.	s.
Lactate,	8	93	. . .	. . .	. . .
Meconate,	25	v. s.	. . .	. . .	. . .
Sulphate,	21	702	n. ins.	. . .	5
Tartrate,	10	v. s.	. . .	. . .	. . .
Naphthalin,	ins.	15	v. s.	v. s.	. . .
Naphthol (Alpha),	s.	v. s.	v. s.	. . .	. . .
(Beta),	1000	0.75	v. s.	v. s.	. . .
Narceine,	1200	800	ins.	. . .	. . .

TABLE OF SOLUBILITIES.—*Continued.*

MEDICINAL SUBSTANCES. One part is soluble in [at 59° F. (15° C.) U. S. P. Standard Temperature.]	PARTS OF				
	Water.	Alcohol.	Ether.	Chloroform.	Glycerin.
Narceine, Hydrochlorate,	s.	v. s.	...	...	...
Narcotine,	n. ins.	80	35	3	...
Nickel Acetate,	6	ins.	...	...	...
Bromide,	s.	s.	s.	...	...
Nitrate,	2	s.	...	...	...
Phosphate,	ins.	...	...	...	...
Sulphate,	4	ins.	ins.	...	...
Nicotine,	v. s.	v. s.	s.	s.	...
Hydrochlorate,	v. s.	v. s.	ins.	...	...
Nitroglycerin,	n. ins.	v. s.	s.	...	...
Orexin,	...	s.	...	...	...
Pancreatin,	s.	ins.	...	...	...
Papaverine,	ins.	sp.	s.	s.	...
Paraffin,	ins.	ins.	s.	s.	...
Paraldehyde,	8.5	s.	s.	...	...
Pelletierine,	v. s.	v. s.	v. s.	v. s.	...
Tannate,	700	80	...	...	...
Pepsin,	100	ins.	ins.	ins.	...
Petrolatum,	ins.	ins.	s.	s.	...
Phenacetin,	sp.	16	...	...	s.
Phenocoll Hydrochlorate,	16	...	...	...	...
Phenyl Hydrazine,	sp.	v. s.	v. s.	...	...
Phosphorus,	ins.	s.	80	v. s.	500
Physostigmine,	sp.	v. s.	v. s.	s.	...
Salicylate,	130	12	...	...	...
Sulphate,	s.	...	...	...	...
Picrotoxin,	240	9	sl.	sl.	...
Pilocarpine,	s.	v. s.	s.	s.	...
Hydrochlorate,	v. s.	v. s.	n. ins.	n. ins.	...
Hydrobromate,	s.	s.	...	s.	...
Nitrate,	9	40	s.	...	...
Sulphate,	s.	s.	s.	s.	...
Piperazine,	v. s.	...	...	...	...
Piperin,	n. ins.	30	sl.	s.	...
Podophyllin,	n. ins.	s.	sp.	...	...
Potassa, Sulphurated,	2	sp.	...	...	...
Potassium Acetate,	0.36	1.9	ins.	...	...
Arseniate,	5.3	25	...	...	2
Arsenite,	v. s.	sp.	...	...	...
Benzoate,	v. s.	...	...	...	...
Bicarbonate,	3.2	n. ins.	ins.	...	...
Bichromate,	10	ins.	ins.	...	...
Bisulphate,	2	ins.	...	...	...
Bisulphite,	v. s.	...	...	...	...
Bitartrate,	201	sp.	ins.	...	...
Bromide,	1.6	200	ins.	...	4
Carbonate,	1.1	ins.	ins.	...	...
Chlorate,	16.7	sp.	ins.	...	80
Chloride,	3	s.	ins.	...	30
Citrate,	0.6	sp.	...	...	...
Cyanide,	2	sp.	...	...	3.5
Ferricyanide,	4	sp.	...	...	...
Ferrocyanide,	4	ins.	...	...	...
Hydrate,	0.5	2	sl.	...	...
Hypophosphite,	0.6	7.3	...	...	...
Iodide,	0.75	18	ins.	...	2.5
Nitrate,	3.8	sp.	ins.	...	...
Nitrite,	v. s.	...	...	...	...
Oxalate,	s.	...	...	...	...
Permanganate.	16	dec.	ins.	...	...
Phosphate,	s.	...	...	...	...
Salicylate,	s.	s.	ins.	...	...
Sulphate,	9.5	ins.	ins.	...	...
Tartrate,	1	ins.	ins.	...	...
and Sodium Tartrate,	1.4	n. ins.	ins.	...	...
Pyoktanin,	75	12	ins.	s.	50
Pyridine,	s.	v. s.	v. s.	...	...
Nitrate,	v. s.	sp.	...	...	...
Sulphate,	v. s.	v. s.	...	...	...
Pyrodine Hydrochlorate,	sp.	v. s.	ins.	...	..
Pyrogallol,	1.7	1	1.2	...	...
Quinidine,	2000	20	80	...	...
Hydrochlorate,	27	v. s.	ins.	...	...

TABLE OF THERMOMETRIC EQUIVALENTS.—*Continued.*

C.°	F.°	C.°	F.°	C.°	F.°	C.°	F.°
95.5556	**204**	115.5556	**240**	135.5556	**276**	155.5556	**312**
96	204.8	**116**	240.8	**136**	276.8	**156**	312.8
96.1111	**205**	116.1111	**241**	136.1111	**277**	156.1111	**313**
96.6667	**206**	116.6667	**242**	136.6667	**278**	156.6667	**314**
97	206.6	**117**	242.6	**137**	278.6	**157**	314.6
97.2222	**207**	117.2222	**243**	137.2222	**279**	157.2222	**315**
97.7778	**208**	117.7778	**244**	137.7778	**280**	157.7778	**316**
98	208.4	**118**	244.4	**138**	280.4	**158**	316.4
98.3333	**209**	118.3333	**245**	138.3333	**281**	158.3333	**317**
98.8889	**210**	118.8889	**246**	138.8889	**282**	158.8889	**318**
99	210.2	**119**	246.2	**139**	282.2	**159**	318.2
99.4444	**211**	119.4444	**247**	139.4444	**283**	159.4444	**319**
100	**212**	**120**	**248**	**140**	**284**	**160**	**320**
100.5556	**213**	120.5556	**249**	140.5556	**285**	160.5556	**321**
101	213.8	**121**	249.8	**141**	285.8	**161**	321.8
101.1111	**214**	121.1111	**250**	141.1111	**286**	161.1111	**322**
101.6667	**215**	121.6667	**251**	141.6667	**287**	161.6667	**323**
102	215.6	**122**	251.6	**142**	287.6	**162**	323.6
102.2222	**216**	122.2222	**252**	142.2222	**288**	162.2222	**324**
102.7778	**217**	122.7778	**253**	142.7778	**289**	162.7778	**325**
103	217.4	**123**	253.4	**143**	289.4	**163**	325.4
103.3333	**218**	123.3333	**254**	143.3333	**290**	163.3333	**326**
103.8889	**219**	123.8889	**255**	143.8889	**291**	163.8889	**327**
104	219.2	**124**	255.2	**144**	291.2	**164**	327.2
104.4444	**220**	124.4444	**256**	144.4444	**292**	164.4444	**328**
105	**221**	**125**	**257**	**145**	**293**	**165**	**329**
105.5556	**222**	125.5556	**258**	145.5556	**294**	165.5556	**330**
106	222.8	**126**	258.8	**146**	294.8	**166**	330.8
106.1111	**223**	126.1111	**259**	146.1111	**295**	166.1111	**331**
106.6667	**224**	126.6667	**260**	146.6667	**296**	166.6667	**332**
107	224.6	**127**	260.6	**147**	296.6	**167**	332.6
107.2222	**225**	127.2222	**261**	147.2222	**297**	167.2222	**333**
107.7778	**226**	127.7778	**262**	147.7778	**298**	167.7778	**334**
108	226.4	**128**	262.4	**148**	298.4	**168**	334.4
108.3333	**227**	128.3333	**263**	148.3333	**299**	168.3333	**335**
108.8889	**228**	128.8889	**264**	148.8889	**300**	168.8889	**336**
109	228.2	**129**	264.2	**149**	300.2	**169**	336.2
109.4444	**229**	129.4444	**265**	149.4444	**301**	169.4444	**337**
110	**230**	**130**	**266**	**150**	**302**	**170**	**338**
110.5556	**231**	130.5556	**267**	150.5556	**303**	170.5556	**339**
111	231.8	**131**	267.8	**151**	303.8	**171**	339.8
111.1111	**232**	131.1111	**268**	151.1111	**304**	171.1111	**340**
111.6667	**233**	131.6667	**269**	151.6667	**305**	171.6667	**341**
112	233.6	**132**	269.6	**152**	305.6	**172**	341.6
112.2222	**234**	132.2222	**270**	152.2222	**306**	172.2222	**342**
112.7778	**235**	132.7778	**271**	152.7778	**307**	172.7778	**343**
113	235.4	**133**	271.4	**153**	307.4	**173**	343.4
113.3333	**236**	133.3333	**272**	153.3333	**308**	173.3333	**344**
113.8889	**237**	133.8889	**273**	153.8889	**309**	173.8889	**345**
114	237.2	**134**	273.2	**154**	309.2	**174**	345.2
114.4444	**238**	134.4444	**274**	154.4444	**310**	174.4444	**346**
115	**239**	**135**	**275**	**155**	**311**	**175**	**347**

TABLE OF THERMOMETRIC EQUIVALENTS.—*Continued.*

C.°	F.°	C.°	F.°	C.°	F.°	C.°	F.°
175.5556	**348**	195.5556	**384**	215.5556	**420**	235.5556	**456**
176	348.8	**196**	384.8	**216**	420.8	**236**	456.8
176.1111	**349**	196.1111	**385**	216.1111	**421**	236.1111	**457**
176.6667	**350**	196.6667	**386**	216.6667	**422**	236.6667	**458**
177	350.6	**197**	386.6	**217**	422.6	**237**	458.6
177.2222	**351**	197.2222	**387**	217.2222	**423**	237.2222	**459**
177.7778	**352**	197.7778	**388**	217.7778	**424**	237.7778	**460**
178	352.4	**198**	388.4	**218**	424.4	**238**	460.4
178.3333	**353**	198.3333	**389**	218.3333	**425**	238.3333	**461**
178.8889	**354**	198.8889	**390**	218.8889	**426**	238.8889	**462**
179	354.2	**199**	390.2	**219**	426.2	**239**	462.2
179.4444	**355**	199.4444	**391**	219.4444	**427**	239.4444	**463**
180	**356**	**200**	**392**	**220**	**428**	**240**	**464**
180.5556	**357**	200.5556	**393**	220.5556	**429**	240.5556	**465**
181	357.8	**201**	393.8	**221**	429.8	**241**	465.8
181.1111	**358**	201.1111	**394**	221.1111	**430**	241.1111	**466**
181.6667	**359**	201.6667	**395**	221.6667	**431**	241.6667	**467**
182	359.6	**202**	395.6	**222**	431.6	**242**	467.6
182.2222	**360**	202.2222	**396**	222.2222	**432**	242.2222	**468**
182.7778	**361**	202.7778	**397**	222.7778	**433**	242.7778	**469**
183	361.4	**203**	397.4	**223**	433.4	**243**	469.4
183.3333	**362**	203.3333	**398**	223.3333	**434**	243.3333	**470**
183.8889	**363**	203.8889	**399**	223.8889	**435**	243.8889	**471**
184	363.2	**204**	399.2	**224**	435.2	**244**	471.2
184.4444	**364**	204.4444	**400**	224.4444	**436**	244.4444	**472**
185	**365**	**205**	**401**	**225**	**437**	**245**	**473**
185.5556	**366**	205.5556	**402**	225.5556	**438**	245.5556	**474**
186	366.8	**206**	402.8	**226**	438.8	**246**	474.8
186.1111	**367**	206.1111	**403**	226.1111	**439**	246.1111	**475**
186.6667	**368**	206.6667	**404**	226.6667	**440**	246.6667	**476**
187	368.6	**207**	404.6	**227**	440.6	**247**	476.6
187.2222	**369**	207.2222	**405**	227.2222	**441**	247.2222	**477**
187.7778	**370**	207.7778	**406**	227.7778	**442**	247.7778	**478**
188	370.4	**208**	406.4	**228**	442.4	**248**	478.4
188.3333	**371**	208.3333	**407**	228.3333	**443**	248.3333	**479**
188.8889	**372**	208.8889	**408**	228.8889	**444**	248.8889	**480**
189	372.2	**209**	408.2	**229**	444.2	**249**	480.2
189.4444	**373**	209.4444	**409**	229.4444	**445**	249.4444	**481**
190	**374**	**210**	**410**	**230**	**446**	**250**	**482**
190.5556	**375**	210.5556	**411**	230.5556	**447**	250.5556	**483**
191	375.8	**211**	411.8	**231**	447.8	**251**	483.8
191.1111	**376**	211.1111	**412**	231.1111	**448**	251.1111	**484**
191.6667	**377**	211.6667	**413**	231.6667	**449**	251.6667	**485**
192	377.6	**212**	413.6	**232**	449.6	**252**	485.6
192.2222	**378**	212.2222	**414**	232.2222	**450**	252.2222	**486**
192.7778	**379**	212.7778	**415**	232.7778	**451**	252.7778	**487**
193	379.4	**213**	415.4	**233**	451.4	**253**	487.4
193.3333	**380**	213.3333	**416**	233.3333	**452**	253.3333	**488**
193.8889	**381**	213.8889	**417**	233.8889	**453**	253.8889	**489**
194	381.2	**214**	417.2	**234**	453.2	**254**	489.2
194.4444	**382**	214.4444	**418**	234.4444	**454**	254.4444	**490**
195	**383**	**215**	**419**	**235**	**455**	**255**	**491**

TABLE OF THERMOMETRIC EQUIVALENTS.—*Continued.*

C.°	F.°	C.°	F.°	C.°	F.°	C.°	F.°
255.5556	**492**	275.5556	**528**	295.5556	**564**	315.5556	**600**
256	492.8	**276**	528.8	**296**	564.8	**316**	600.8
256.1111	**493**	276.1111	**529**	296.1111	**565**	316.1111	**601**
256.6667	**494**	276.6667	**530**	296.6667	**566**	316.6667	**602**
257	494.6	**277**	530.6	**297**	566.6	**317**	602.6
257.2222	**495**	277.2222	**531**	297.2222	**567**	317.2222	**603**
257.7778	**496**	277.7778	**532**	297.7778	**568**	317.7778	**604**
258	496.4	**278**	532.4	**298**	568.4	**318**	604.4
258.3333	**497**	278.3333	**533**	298.3333	**569**	318.3333	**605**
258.8889	**498**	278.8889	**534**	298.8889	**570**	318.8889	**606**
259	498.2	**279**	534.2	**299**	570.2	**319**	606.2
259.4444	**499**	279.4444	**535**	299.4444	**571**	319.4444	**607**
260	**500**	**280**	**536**	**300**	**572**	**320**	**608**
260.5556	**501**	280.5556	**537**	300.5556	**573**	320.5556	**609**
261	501.8	**281**	537.8	**301**	573.8	**321**	609.8
261.1111	**502**	281.1111	**538**	301.1111	**574**	321.1111	**610**
261.6667	**503**	281.6667	**539**	301.6667	**575**	321.6667	**611**
262	503.6	**282**	539.6	**302**	575.6	**322**	611.6
262.2222	**504**	282.2222	**540**	302.2222	**576**	322.2222	**612**
262.7778	**505**	282.7778	**541**	302.7778	**577**	322.7778	**613**
263	505.4	**283**	541.4	**303**	577.4	**323**	613.4
263.3333	**506**	283.3333	**542**	303.3333	**578**	323.3333	**614**
263.8889	**507**	283.8889	**543**	303.8889	**579**	323.8889	**615**
264	507.2	**284**	543.2	**304**	579.2	**324**	615.2
264.4444	**508**	284.4444	**544**	304.4444	**580**	324.4444	**616**
265	**509**	**285**	**545**	**305**	**581**	**325**	**617**
265.5556	**510**	285.5556	**546**	305.5556	**582**	325.5556	**618**
266	510.8	**286**	546.8	**306**	582.8	**326**	618.8
266.1111	**511**	286.1111	**547**	306.1111	**583**	326.1111	**619**
266.6667	**512**	286.6667	**548**	306.6667	**584**	326.6667	**620**
267	512.6	**287**	548.6	**307**	584.6	**327**	620.6
267.2222	**513**	287.2222	**549**	307.2222	**585**	327.2222	**621**
267.7778	**514**	287.7778	**550**	307.7778	**586**	327.7778	**622**
268	514.4	**288**	550.4	**308**	586.4	**328**	622.4
268.3333	**515**	288.3333	**551**	308.3333	**587**	328.3333	**623**
268.8889	**516**	288.8889	**552**	308.8889	**588**	328.8889	**624**
269	516.2	**289**	552.2	**309**	588.2	**329**	624.2
269.4444	**517**	289.4444	**553**	309.4444	**589**	329.4444	**625**
270	**518**	**290**	**554**	**310**	**590**	**330**	**626**
270.5556	**519**	290.5556	**555**	310.5556	**591**	330.5556	**627**
271	519.8	**291**	555.8	**311**	591.8	**331**	627.8
271.1111	**520**	291.1111	**556**	311.1111	**592**	331.1111	**628**
271.6667	**521**	291.6667	**557**	311.6667	**593**	331.6667	**629**
272	521.6	**292**	557.6	**312**	593.6	**332**	629.6
272.2222	**522**	292.2222	**558**	312.2222	**594**	332.2222	**630**
272.7778	**523**	292.7778	**559**	312.7778	**595**	332.7778	**631**
273	523.4	**293**	559.4	**313**	595.4	**333**	631.4
273.3333	**524**	293.3333	**560**	313.3333	**596**	333.3333	**632**
273.8889	**525**	293.8889	**561**	313.8889	**597**	333.8889	**633**
274	525.2	**294**	561.2	**314**	597.2	**334**	633.2
274.4444	**526**	294.4444	**562**	314.4444	**598**	334.4444	**634**
275	**527**	**295**	**563**	**315**	**599**	**335**	**635**

EQUIVALENTS OF WEIGHTS AND MEASURES,*

CUSTOMARY AND METRIC.

NOTE.—The values given for the relation of weight to measure are for Water at the temperature of 4° C. (39.2° F.) *in vacuo*. For ordinary, practical purposes, these values may be used, without correction.

Weights, Customary.						Metric Weight and Measure.	Measures, Customary.		
Grains.	Troy		Avoirdupois			Gm.] [Cc.	Fluid		Fluid-ounces and fractions.
	oz.	grains.	lbs.	oz.	grains.		ounces.	minims.	
15432.4	32	72.4	2	3	119.9	1000	33	390.6	33.814
15360	32	......	2	3	47.5	995.312	33	314.5	33.655
15060.9	31	180.9	2	2	185.9	975.932	33	......	33
15046.6	31	166.6	2	2	171.6	975	32	464.9	32.968
14880	31	......	2	2	5	964.208	32	289.7	32.604
14660.7	30	260.7	2	1	223.2	950	32	59.1	32.123
14604.5	30	204.5	2	1	167	946.358	32	......	32
14400	30	......	2	...	400	933.105	31	264.9	31.552
14274.9	29	354.9	2	...	274.9	925	31	133.3	31.278
14148.2	29	228.2	2	...	148.2	916.785	31	......	31
14000	29	80	2	..	......	907.185	30	324.2	30.676
13920	29	......	1	15	357.5	902.000	30	240	30.500
13889.1	28	449.1	1	15	326.6	900	30	207.6	30.432
13691.8	28	251.8	1	15	129.3	887.211	30	......	30
13562.5	28	122.5	1	15	......	878.635	29	344.1	29.717
13503.3	28	63.3	1	14	378.3	875	29	281.8	29.587
13440	28	......	1	14	315	870.898	29	215.2	29.448
13235.4	27	275.4	1	14	110.4	857.637	29	......	29
13125	27	165	1	14	......	850.486	28	363.9	28.759
13117.5	27	157.5	1	13	430	850	28	356	28.742
12960	27	......	1	13	272.5	839.794	28	190.4	28.397
12779	26	299	1	13	91.5	828.064	28	......	28
12731.7	26	251.7	1	13	44.2	825	27	430.3	27.896
12687.5	26	207.5	1	13	......	822.136	27	383.8	27.800
12480	26	......	1	12	230	808.691	27	165.6	27.345
12345.9	25	345.9	1	12	95.9	800	27	24.5	27.051
12322.6	25	322.6	1	12	72.6	798.490	27	......	27
12250	25	250	1	12	......	793.787	26	403.7	26.841
12000	25	......	1	11	187.5	777.587	26	140.7	26.293
11960.1	24	440.1	1	11	147.6	775	26	98.7	26.206
11866.2	24	346.2	1	11	53.7	768.916	26	......	26
11812.5	24	292.5	1	11	......	765.437	25	423.6	25.883
11574.3	24	54.3	1	10	199.3	750	25	173	25.360
11520	24	......	1	10	145	746.484	25	115.9	25.241
11409.8	23	369.8	1	10	34.8	739.343	25	......	25
11375	23	335	1	10	.....	737.087	24	443.4	24.924
11188.5	23	148.5	1	9	251	725	24	247.2	24.515
11040	23	......	1	9	102.5	715.380	24	91.1	24.190
10953.4	22	393.4	1	9	15.9	709.769	24	......	24
10937.5	22	377.5	1	9	......	708.738	23	463.3	23.966

* Taken from U. S. Pharmacopœia, 1890.

EQUIVALENTS OF WEIGHTS AND MEASURES.—*Continued.*

Weights, Customary.						Metric Weight and Measure.	Measures, Customary.		
Grains.	Troy		Avoirdupois				Fluid		Fluid-ounces and fractions.
	oz.	grains.	lbs.	oz.	grains.	Gm.] [Cc.	ounces.	minims.	
10802.6	22	242.6	1	8	302.6	**700**	23	321.4	23.670
10560	**22**	......	1	8	60	684.277	23	66.2	23.138
10500	21	420	**1**	**8**	......	680.388	23	3.1	23.007
10497.0	21	417	1	7	434.5	680.195	**23**	......	**23**
10416.8	21	336.8	1	7	354.3	**675**	22	395.7	22.824
10080	**21**	......	1	7	17.5	653.173	22	41.4	22.086
10062.5	20	462.5	**1**	**7**	......	652.039	22	23.0	22.048
10040.6	20	440.6	1	6	415.6	650.621	**22**	......	**22**
10031.0	20	431	1	6	406	**650**	21	469.9	21.979
9645.2	20	45.2	1	6	20.2	**625**	21	64.1	21.134
9625	20	25	**1**	**6**	......	623.689	21	42.9	21.09
9600	**20**	......	1	5	412.5	622.070	21	16.6	21.035
9584.2	19	464.2	1	5	396.7	621.048	**21**	......	**21**
9259.4	19	139.4	1	5	71.9	**600**	20	138.4	20.288
9187.5	19	67.5	**1**	**5**	......	595.340	20	62.7	20.131
9127.8	19	7.8	1	4	377.8	591.474	**20**	......	**20**
9120	**19**	......	1	4	370	590.966	19	471.8	19.983
8873.6	18	233.6	1	4	123.6	**575**	19	212.6	19.443
8750	18	110	**1**	**4**	......	566.990	19	82.6	19.172
8671.4	18	31.4	1	3	358.9	561.900	**19**	......	**19**
8640	**18**	......	1	3	327.5	559.863	18	447	18.931
8487.8	17	327.8	1	3	175.3	**550**	18	286.8	18.598
8312.5	17	152.5	**1**	**3**	......	538.641	18	102.5	18.214
8215.1	17	55.1	1	2	340.1	532.327	**18**	......	**18**
8160	**17**	......	1	2	285	528.759	17	422.1	17.880
8102	16	422	1	2	227	**525**	17	361.1	17.752
7875	16	195	**1**	**2**	......	510.291	17	122.4	17.255
7758.7	16	78.7	1	1	321.2	502.753	**17**	......	**17**
7716.2	16	36.2	1	1	278.7	**500**	16	435.3	16.907
7680	**16**	......	1	1	242.5	497.656	16	397.2	16.828
7437.5	15	237.5	**1**	**1**	......	481.942	16	142.2	16.297
7330.4	15	130.4	1	...	330.4	**475**	16	29.6	16.062
7302.3	15	102.3	1	...	302.3	473.179	**16**	......	**16**
7200	**15**	......	1	...	200	466.552	15	372.4	15.776
7000	14	280	**1**	...	......	453.592	15	162.1	15.338
6944.6	14	224.6	...	15	382.1	**450**	15	103.8	15.216
6845.9	14	125.9	...	15	283.4	443.606	**15**	......	**15**
6720	**14**	......	...	15	157.5	435.449	14	347.6	14.724
6562.5	13	322.5	...	**15**	......	425.243	14	182	14.379
6558.8	13	318.8	...	14	433.8	**425**	14	178.0	14.371
6389.5	13	149.5	...	14	264.5	414.032	**14**	......	**14**
6240	**13**	......	...	14	115	404.345	13	322.8	13.672

EQUIVALENTS OF WEIGHTS AND MEASURES.—*Continued.*

Weights, Customary.						Metric Weight and Measure.	Measures, Customary.		
Grains.	Troy		Avoirdupois			Gm.] [Cc.	Fluid		Fluid-ounces and fractions.
	oz.	grains.	lbs.	oz.	grains.		ounces.	minims.	
6172.9	12	412.9	...	14	47.9	**400**	13	252.3	13.526
6125	12	365	...	**14**	......	396.893	13	201.8	13.421
5933.1	12	173.1	...	13	245.6	384.458	**13**	......	**13**
5787.1	12	27.1	...	13	99.6	**375**	12	326.5	12.680
5760	**12**	......	...	13	72.5	373.242	12	298	12.621
5687.5	11	407.5	...	**13**	......	368.544	12	221.7	12.462
5476.7	11	196.7	...	12	226.7	354.884	**12**	......	**12**
5401.3	11	121.3	...	12	151.3	**350**	11	400.7	11.835
5280	**11**	......	...	12	30	342.138	11	273.1	11.570
5250	10	450	...	**12**	......	340.194	11	241.6	11.503
5020.3	10	220.3	...	11	207.8	325.311	**11**	......	**11**
5015.5	10	215.5	...	11	203	**325**	10	475	10.989
4812.5	10	12.5	...	**11**	......	311.845	10	261.4	10.545
4800	**10**	......	...	10	425	311.035	10	248.3	10.517
4629.7	9	309.7	...	10	254.7	**300**	10	69.2	10.144
4563.9	9	243.9	...	10	188.9	295.737	**10**	......	**10**
4375	9	55	...	**10**	......	283.495	9	281.3	9.586
4320	**9**	......	...	9	382.5	279.930	9	223.5	9.466
4244	8	404	...	9	306.5	**275**	9	143.4	9.299
4107.5	8	267.5	...	9	170	266.163	**9**	......	**9**
3937.5	8	97.5	...	**9**	......	255.146	8	301.2	8.628
3858.1	8	18.1	...	8	358.1	**250**	8	217.7	8.453
3840	**8**	......	...	8	340	248.828	8	198.6	8.414
3651.1	7	291.1	...	8	151.1	236.590	**8**	......	**8**
3500	7	140	...	**8**	......	226.796	7	321.0	7.669
3472.3	7	112.3	...	7	409.8	**225**	7	291.9	7.608
3360	**7**	......	...	7	297.5	217.724	7	173.8	7.362
3194.7	6	314.7	...	7	132.2	207.016	**7**	.....	**7**
3086.5	6	206.5	...	7	24	**200**	6	366.1	6.763
3062.5	6	182.5	...	**7**	......	198.447	6	340.9	6.710
2880	**6**	......	...	6	255	186.621	6	149	6.310
2738.4	5	338.4	...	6	113.4	177.442	**6**	......	**6**
2700.7	5	300.7	...	6	75.7	**175**	5	440.4	5.917
2625	5	225	...	**6**	......	170.097	5	360.8	5.752
2400	**5**	......	...	5	212.5	155.517	5	124.1	5.259
2314.9	4	394.9	...	5	127.4	**150**	5	34.6	5.072
2282	4	362	...	5	94.5	147.869	**5**	......	**5**
2187.5	4	267.5	...	**5**	......	141.748	4	380.7	4.793
1929	4	9	...	4	179	**125**	4	108.8	4.227
1920	**4**	......	..	4	170	124.414	4	99.3	4.207
1825.6	3	385.6	...	4	75.6	118.295	**4**	......	**4**
1750	3	310	...	**4**	......	113.398	3	400.5	3.834

EQUIVALENTS OF WEIGHTS AND MEASURES.—*Continued.*

Weights, Customary.						Metric Weight and Measure.	Measures, Customary.		
Grains.	Troy.		Avoirdupois				Fluid		Fluid-ounces and fractions.
	oz.	grains.	lbs.	oz.	grains.	Gm.] [Cc.	ounces.	minims.	
1543.2	3	103.2	...	3	230.7	**100**	3	183.1	3.381
1440	**3**	......	...	3	127.5	93.310	3	74.5	3.155
1388.9	2	428.9	...	3	76.4	**90**	3	20.8	3.043
1369.2	2	409.2	...	3	56.7	88.721	**3**	......	**3**
1312.5	2	352.5	...	**3**	......	85.049	**2**	420.4	2.876
1234.6	2	274.6	...	2	359.6	**80**	2	338.5	2.705
1157.4	2	197.4	...	2	282.4	**75**	2	257.3	2.536
1080.3	2	120.3	...	2	205.3	**70**	2	176.1	2.367
960	**2**	......	...	2	85	62.207	2	49.7	2.103
925.9	1	445.9	...	2	50.9	**60**	2	13.8	2.029
912.8	1	432.8	...	2	37.8	59.147	**2**	......	**2**
875	1	395	...	**2**	......	59.699	1	440.3	1.917
771.6	1	291.6	...	1	334.1	**50**	1	331.5	1.691
617.3	1	137.3	...	1	179.8	**40**	1	169.2	1.353
480	**1**	......	...	1	42.5	31.1035	1	24.8	1.052
463	...	......	...	1	25.4	**30**	1	6.9	1.014
456.392	...	......	...	1	18.89	29.574	**1**	......	**1**
437.5	...	......	...	**1**	......	28.350	...	460.1307	0.959
385.8	...	......	...	...	......	**25**	...	405.8	0.845
308.6	...	......	...	...	......	**20**	...	324.61	0.676
154.3	...	......	...	..	......	**10**	...	162.31	0.338
15.4324	...	......	...	...	......	**1**	...	16.23	0.034
1	...	.....	...	...	......	0.06479	...	1.0517	0.0022
0.9508	...	......	...	...	......	0.06161	...	**1**	0.0021

EQUIVALENTS OF WEIGHTS AND MEASURES.—*Continued.*

FROM 1 TROY OUNCE DOWN.

Grains.	Metric Weight and Measure. Gm.] [Cc.	Minims (of Water at 4° C.).	Grains.	Metric Weight and Measure. Gm.] [Cc.	Minims (of Water at 4° C.).
480 [1 ℥	31.103	504.8	**240** [4 ʒ	15.551	252.4
478.4	**31**	503.1	231.5	**15**	243.4
475.4	30.805	**500**	228.2	14.786	**240**
463.0	**30**	486.9	**218.75** [½ av. oz.	14.175	230.1
456.4	29.573	**480**	216.1	**14**	227.2
450	29.159	473.3	**210**	13.607	220.9
447.5	**29**	470.7	200.6	**13**	211
437.5 [1 av. oz.	28.350	460.1	199.7	12.938	**210**
432.1	**28**	454.4	185.2	**12**	194.8
427.9	27.724	**450**			
420 [7 ʒ	27.214	441.7	**180** [3 ʒ	11.663	189.3
416.7	**27**	438.2	171.1	11.090	**180**
401.2	**26**	422	169.8	**11**	178.5
399.3	25.876	**420**	154.3	**10**	162.3
390	25.271	410.2	**150**	9.719	157.8
385.8	**25**	405.7	142.6	9.241	**150**
380.3	24.644	**400**	138.9	**9**	146.1
370.8	24.028	**390**	123.5	**8**	129.8
370.4	**24**	389.5			
360 [6 ʒ	23.327	378.6	**120** [2 ʒ	7.775	126.2
354.9	**23**	373.3	114.1	7.393	**120**
342.3	22.180	**360**	**109.37** [¼ av. oz.	7.088	115.9
339.5	**22**	357.1	108.0	**7**	113.6
330	21.383	347.1	**100**	6.480	105.2
324.1	**21**	340.8	95.1	6.161	**100**
313.8	20.331	**330**	92.6	**6**	97.4
308.6	**20**	324.6	**80**	5.184	84.1
			77.2	**5**	81.1
			76.1	4.928	**80**
			61.7	**4**	64.9
300 [5 ʒ	19.440	315.5	**60** [1 ʒ	3.888	63.1
293.2	**19**	308.4	57.0	3.696	**60**
285.2	18.483	**300**	**54.69** [⅛ av. oz.	3.544	57.5
277.8	**18**	292.1	47.5	3.080	**50**
270	17.495	284.0	**50**	3.240	52.6
262.3	**17**	275.9	46.3	**3**	48.7
256.7	16.635	**270**	42.8	2.772	**45**
246.9	**16**	259.7	**40**	2.592	42.1
			38.0	2.464	**40**
			33.3	2.156	**35**
			30.9	**2**	32.5

EQUIVALENTS OF WEIGHTS AND MEASURES.—*Continued.*

CONTINUATION OF TABLE OF EQUIVALENTS FROM 1 TROY OUNCE DOWN.

Grains.	Metric Weight and Measure. Gm.] [Cc.	Minims (of Water at 4° C.).
30 [½ ℥	1.944	31.6
28.5	1.848	**30**
23.8	1.540	**25**
20	1.296	21.0
19.0	1.232	**20**
15.4324	**1**	16.23
15	0.972	15.9
14.3	0.924	**15**
14	0.907	14.7
13.3	0.862	**14**
13	0.842	13.7
12.4	0.801	**13**
12	0.775	12.6
11.4	0.739	**12**
11	0.713	11.6
10.5	0.678	**11**
10	0.648	10.5
9.5	0.616	**10**
9	0.583	9.5
8.6	0.554	**9**
8	0.518	8.4
7.7	**0.5**	8.1
7.6	0.493	**8**
7	0.454	7.4
6.7	0.431	**7**
6	0.389	6.3
5.7	0.370	**6**
5	0.324	5.3
4.8	0.308	**5**
4	0.259	4.2
3.8	0.246	**4**
3	0.194	3.2
2.9	0.185	**3**
2	0.130	2.1
1.9	0.123	**2**
1	0.065	1.0517
0.9508	0.06161	**1**

EQUIVALENTS OF WEIGHTS FROM 5 GRAINS DOWN.

Grammes.	Grains in decimal fractions.	Grains in common fractions (approximate)
0.324	**5**	**5**
0.291	4.5	4½
0.259	**4**	**4**
0.226	3.5	3½
0.194	**3**	**3**
0.162	2.5	2½
0.130	**2**	**2**
0.097	1.5	1½
0.065	**1**	**1**
0.061	0.94	15/16
0.060	0.93	9/10
0.057	0.88	7/8
0.053	0.82	13/16
0.050	0.77	4/5
0.049	0.76	3/4
0.045	0.69	11/16
0.040	0.62	10/16
0.036	0.56	9/16
0.032	**0.5**	1/2
0.028	0.43	7/16
0.025	0.39	2/5
0.024	0.37	3/8
0.020	0.31	5/16
0.016	0.24	1/4
0.012	0.18	3/16
0.008	0.12	1/8
0.004	0.06	1/16
0.0032	0.05	1/20
0.0027	0.04	1/25
0.0022	0.033	1/30
0.0018	0.028	1/35
0.0016	0.025	1/40
0.0013	0.02	1/50
0.0011	0.017	1/60
0.001	0.015	1/64
0.0006	0.01	1/100
0.0005	0.008	1/125
0.0004	0.0065	1/150
0.0003	0.005	1/200
0.0002	0.003	1/320
0.0001	0.0015	1/640

EQUIVALENTS OF MEASURES OF LENGTH.

CUSTOMARY AND METRIC.

Centimeters.	Inches.	Centimeters.	Inches.	Millimeters.	Inches in decimal fractions.	Inches in 32ds.
150	59.06	55	21.65	25.4	1.	32/32
145	57.09	53.3	21	25	0.98	...
140	55.12	50.8	20	24	0.94	...
139.7	55	50	19.69	23.8	0.94	30/32
135	53.15	48.3	19	23	0.90	29/32
130	51.18	45.7	18	22.2	0.87	28/32
127.0	50	45	17.72	22	0.87	...
125	49.21	43.2	17	21	0.83	...
120	47.24	40.6	16	20.6	0.81	26/32
115	45.28	40	15.75	20	0.79	...
114.3	45	38.1	15	19.1	0.75	24/32
110	43.31	35.6	14	19	0.75	...
105	41.34	35	13.78	18	0.71	...
101.6	40	33.0	13	17.5	0.69	22/32
100	39.37	30.5	12	17	0.67	...
99.0	39	30	11.81	16	0.63	...
96.5	38	27.9	11	15.9	0.62	20/32
95	37.40	25.4	10	15	0.59	...
93.9	37	25	9.84	14.3	0.56	18/32
91.4	36	22.9	9	14	0.55	...
90	35.43	20.3	8	13	0.51	...
88.9	35	20	7.87	12.7	0.50	16/32
86.4	34	17.8	7	12	0.47	...
85	33.46	15.2	6	11.1	0.44	14/32
83.8	33	15	5.91	11	0.43	...
81.3	32	12.7	5	10	0.39	...
80	31.50	10.2	4	9.5	0.37	12/32
78.7	31	10	3.94	9	0.35	...
76.2	30	9	3.54	8.7	0.34	11/32
75	29.53	8	3.15	8	0.31	...
73.6	29	7.6	3	7.9	0.31	10/32
71.1	28	7	2.76	7.1	0.28	9/32
70	27.56	6	2.36	7	0.28	...
68.6	27	5.1	2	6.4	0.25	8/32
66.0	26	5	1.97	6	0.24	...
65	25.59	4	1.57	5.6	0.22	7/32
63.5	25	3	1.18	5	0.20	...
61.0	24	2.54	1	4.8	0.19	6/32
60	23.62	2	0.78	4	0.16	...
58.4	23	1	0.39	3.2	0.13	4/32
55.9	22			3	0.12	...
				2.4	0.09	3/32
				2	0.08	...
				1.6	0.06	2/32
				1	0.04	...
				0.8	0.03	1/32
				0.1	0.0039	...

PERCENTAGE SOLUTIONS, BASED ON THE APOTHECARIES' WEIGHT.

(EDGAR WRIGHT.)

Parts.	Per cent.	♏xx.	fl. ʒj.	fl. ʒij.	fl. ʒiij.	fl. ʒiv.	fl. ʒv.	fl. ʒvj.	fl. ʒvij.	fl. ℥j.	fl. ℥ij.	fl. ℥iij.	fl. ℥iv.	fl. ℥v.	fl. ℥vj.	fl. ℥viij.	fl. ℥xij.	fl. ℥xvj.	fl. ℥xxxij.
1 in 1000	1/10	1/50	3/50	3/25	1/5	1/4	3/10	9/25	3/7	1/2	1	1 1/2	2	2 2/5	3	3 5/6	5 3/4	7 2/3	15 1/3
1 in 900	1/9	1/45	1/15	1/7	1/5	4/15	1/3	2/5	7/15	8/15	1 1/15	1 3/5	2 2/15	2 2/3	3 1/5	4 1/4	6 2/5	8 1/2	17
1 in 800	1/8	1/40	3/40	3/20	2/9	3/10	3/8	4/9	7/13	3/5	1 1/5	1 4/5	2 2/5	3	3 3/5	4 4/5	7 1/5	9 3/5	19 1/5
1 in 700	1/7	1/35	3/35	1/6	1/4	1/3	3/7	1/2	3/5	2/3	1 3/8	2 1/16	2 3/4	3 3/7	4 1/8	5 1/2	8 1/4	11	21 6/7
1 in 600	1/6	1/30	1/10	1/5	3/10	2/5	1/2	3/5	7/10	4/5	1 3/5	2 2/5	3 1/5	4	4 4/5	6 2/5	9 3/5	12 4/5	25 3/5
1 in 500	1/5	1/25	1/8	1/4	1/3	1/2	3/5	3/4	5/6	1	2	2 7/8	3 5/6	4 4/5	5 3/4	7 2/3	11 1/2	15 1/3	30 3/4
1 in 400	1/4	1/20	3/20	1/3	9/20	3/5	3/4	9/10	1 1/20	1 1/5	2 2/5	3 3/5	4 4/5	6	7 1/5	9 3/5	14 2/5	19 1/5	38 2/5
1 in 300	1/3	1/15	1/5	2/5	3/5	4/5	1	1 1/5	1 2/5	1 3/5	3 1/5	4 4/5	6 2/5	8	9 3/5	12 4/5	19 1/5	25 3/5	51 1/5
1 in 200	1/2	1/10	3/10	3/5	9/10	1 1/5	1 1/2	1 4/5	2 1/10	2 2/5	4 4/5	7 1/5	9 3/5	12	14 2/5	19 1/5	28 4/5	38 2/5	76 4/5
1 in 100	1	1/5	3/5	1 1/5	1 4/5	2 2/5	3	3 3/5	4 1/5	4 4/5	9 3/5	14 2/5	19 1/5	24	28 4/5	38 2/5	57 3/5	76 4/5	153 3/5
1 in 50	2	2/5	1 1/5	2 2/5	3 3/5	4 4/5	6	7 1/5	8 2/5	9 3/5	19 1/5	28 4/5	38 2/5	48	57 3/5	76 4/5	115 1/5	153 3/5	307 1/5
1 in 40	2 1/2	1/2	1 1/2	3	4 1/2	6	7 1/2	9	10 1/2	12	24	36	48	60	72	96	144	192	384
1 in 33 1/3	3	3/5	1 4/5	3 7/11	5 2/5	7 1/5	9	11	12 3/5	14 2/5	29	43 1/5	58 1/5	72	87 1/2	116 1/5	174 1/2	232 2/3	465 1/5
1 in 30	3 1/3	2/3	2	4	6	8	10	12	14	16	32	48	64	80	96	128	192	256	512
1 in 25	4	4/5	2 2/5	4 4/5	7 1/5	9 3/5	12	14 2/5	16 4/5	19 1/5	38 2/5	57 3/5	76 4/5	96	115 1/5	153 3/5	230 2/5	307 1/5	614 2/5
1 in 20	5	1	3	6	9	12	15	18	21	24	48	72	96	120	144	192	288	384	768
1 in 10	10	2	6	12	18	24	30	36	42	48	96	144	192	240	288	384	576	768	1536
1 in 5	20	4	12	24	36	48	60	72	84	96	192	288	384	480	576	768	1152	1536	3072
1 in 4	25	5	15	30	45	60	75	90	105	120	240	360	480	600	720	960	1440	1920	3840
1 in 3	33 1/3	6 2/3	20	40	60	80	100	120	140	160	320	480	640	800	960	1280	1920	2560	5120
1 in 2	50	10	30	60	90	120	150	180	210	240	480	720	960	1200	1440	1920	2880	3840	7680

Rule.—To find the number of grains (Apothecaries' weight) required to make solution of any given percentage, first find the quantity of solution to be made, as given on the top line of table, then by referring to the percentage column, find the percentage desired. Draw lines at right angles on the table from the quantity and percentage figures selected, and the answer will be found where the lines intersect. The percentages are graded from $\frac{1}{10}$ of 1% to 50%,—or their equivalents in parts, from 1 in 1000 to 1 in 2; and the quantities from 20 minims to 32 fluid ounces.

Regardless of the quantity of solution, etc., to be made, the salt or solid must displace its own weight of solvent;—for instance, a

fluidounce of a 1 in 30 (or $3\frac{1}{3}\%$) solution of cocaine must contain 16 grains of the salt, and a sufficient quantity of solvent to make 1 fluidounce of finished product.

The table will also be found of service in the case of solutions of powerful alkaloids and salts, in determining at a glance the exact quantity of the medicament in each prescribed dose of the mixture. For example:—take a prescription calling for 6 fluidounces of a 1 in 1000 solution of iodine trichloride,—to be administered in doses of 1 fluidram. By referring to the table, it will be seen not only that 3 grains of iodine trichloride are required to fill the recipe, but also that each dose of the latter—1 fluidram—contains $\frac{3}{50}$ grain of the medicament.

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